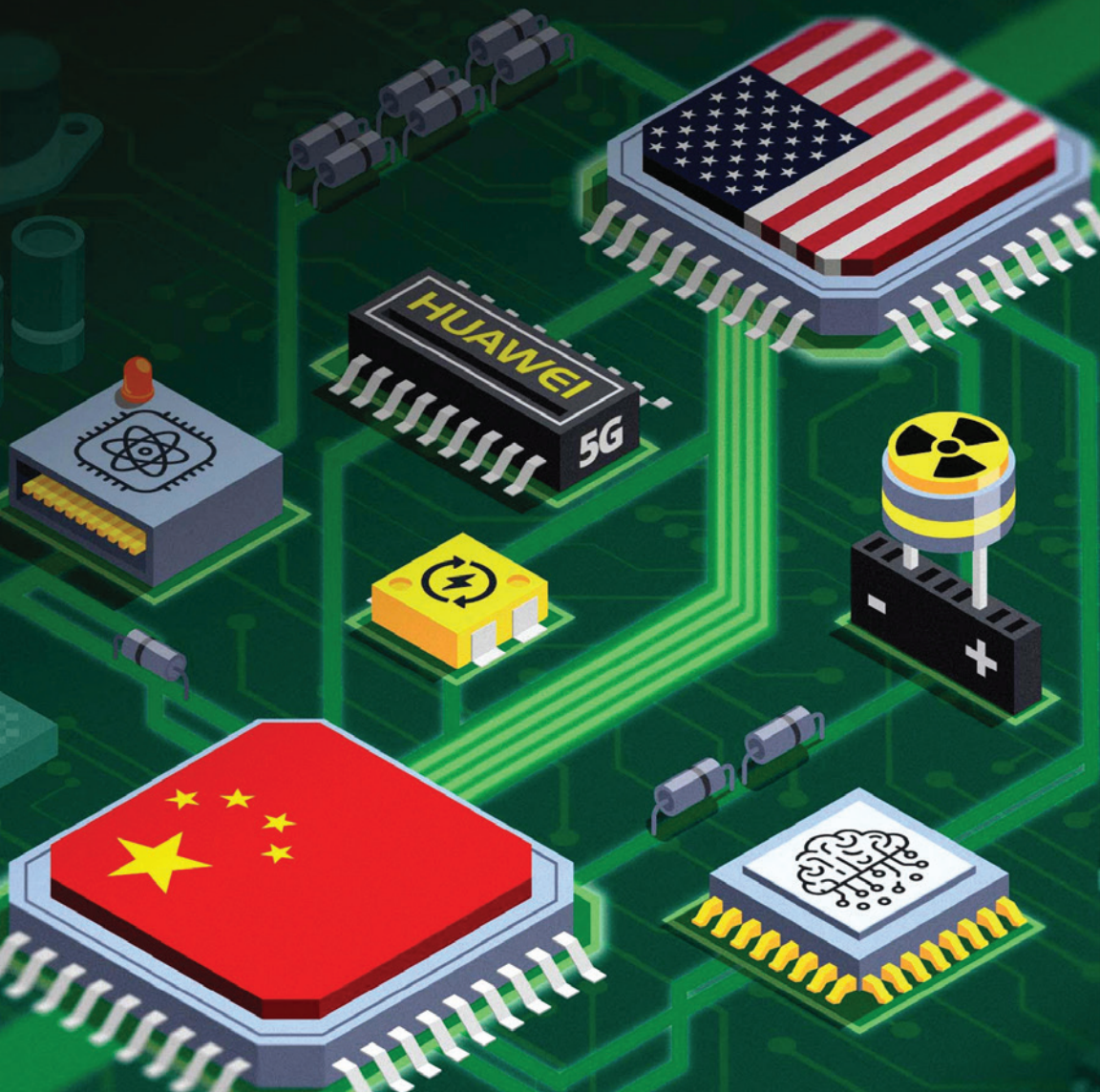
CHINA AND AMERICA'S TECH WAR FROM AI TO 5G

The Struggle to Shape the Future of World Order

A. B. Abrams



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List of Abbreviations

AI: Artificial Intelligence
CCA: Competitive Carriers Association
CIA: Central Intelligence Agency
CFR: Council on Foreign Relations
COVID-19: Coronavirus Disease 2019
CSG: China Strategy Group
CSIS: Centre for Strategic and International Studies
DARPA: Defence Advanced Research Projects Agency
DoD: Department of Defence
EU: European Union
FBI: Federal Bureau of Investigation
FCC: Federal Communications Commission
GCHQ: Government Communications Headquarters
GDP: Gross Domestic Product
GW: Gigawatt
IDC: International Data Corporation
IMF: International Monetary Fund
IP: Intellectual Property
MIT: Massachusetts Institute of Technology
ML: Machine Learning
NATO: North Atlantic Treaty Organisation
NSCAI: National Security Commission on Artificial Intelligence
NDIA: National Defence Industrial Association
NSA: National Security Agency
OECD: Organisation for Economic Co-operation and Development
OLED: Organic Light Emitting Diode
OS: Operating System
PISA: Programme for International Student Assessments
PPP: Purchasing Power Parity
R&D: Research and Development

S&E: Science and Engineering
SARS: Severe Acute Respiratory Syndrome
Sars-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2
SMIC: Semiconductor Manufacturing International Corporation
STEM: Science, Technology, Engineering and Mathematics
TSMC: Taiwan Semiconductor Manufacturing Company
UN: United Nations
US(A): United States (of America)
USSR: Union of Soviet Socialist Republics
WTO: World Trade Organisation
5G: fifth generation broadband cellular networks
6G: sixth generation broadband cellular networks

Preface

The contest for dominance of high-end technologies has increasingly been recognized as the most critical and decisive area of competition between the world's two leading powers China and the United States, described in 2021 by CIA Director William Burns as "main arena for competition and rivalry with China."[1] This book examines prevailing trends in this competition, and details the increasingly central role of the Chinese and American technology sectors both in their worsening geopolitical standoff and in shaping the future of world order. It explores the benefits primacy in key emerging technology areas can bring, the consequences leadership in each area will likely have for the country that attains it, and the comparative strengths of both countries' tech sectors in those areas.

Five broad areas of technological competition with high strategic and economic significance are explored including artificial intelligence, quantum computing, green and nuclear technologies, telecommunications and semiconductor chips. Factors which influence the competitiveness of the two countries' tech sectors in all areas, including the quality of education, the ability to attract foreign talent, and the health of their supporting industrial bases, are also covered in detail, as are the ways in which geopolitics affects competition with the US campaign against the Chinese tech giant Huawei analysed as a key example. The wide scope of the areas covered aims to provide a full picture of all the major factors which will determine the outcome of Sino-US competition in high tech.

The term 'tech war,' although increasingly widely used from 2019, is seldom defined with those definitions that do exist varying greatly. It is defined here as competition in multiple high technology areas of geopolitical importance with the specific goal of gaining a national advantage over the opponent. Such competition has included not only technological development, but also efforts to erode or undermine the tech sector of the rival power. This book was written to provide a detailed understanding of the tech war's

importance, how it is being waged and the factors which will be most important to determining its outcome.

DEFINITIONS

China: References to China's economy such as GDP, life expectancy or coverage of high-speed rail, will refer only to the mainland and exclude Taiwan, Hong Kong and Macao due to their effectively separate economies.

East Asia/Northeast Asia: The region encompassing China, the Koreas and Japan.

Gross Domestic Product (GDP): Throughout this book a country's gross domestic product will be cited with figures that adjust for purchasing power parity. This is generally considered to be a better measure of the size of an economy by economists, as well as by the International Monetary Fund and Central Intelligence Agency. It is based directly on a country's productivity while avoiding incidences where the size of an economy on paper changes by double digits within weeks based on fluctuations in currency markets.

Southeast Asia: Members and observers in the ASEAN including Brunei, Cambodia, East Timor, Indonesia, Laos, Malaysia, Myanmar, Papua New Guinea, the Philippines, Singapore, Thailand and Vietnam.

NOTE

1. 'Transcript: NPR's Full Conversation with CIA Director William Burns,' *NPR*, July 22, 2021.

PART I

Tech War

Chapter 1

The Tech War, Education, and the Battle for Talent

ONE THOUSAND TALENTS: CHINA'S EDUCATION ADVANTAGE

The strength of any country's position to contend for primacy in high end technologies is determined by multiple factors, some of which include its pre-existing industrial base, the size and affluence of its consumer base, and how effectively the private and public sectors or the defense and civilian industrial sectors can synergize and cooperate. Perhaps most important, however, is the level of the country's scientific and technical education and its ability to produce and retain talent. Chinese President Xi Jinping referred to this in 2018 as "the first resource" in his country's push for "independent innovation."[1] Senior Fellow at the Centre for a New American Security, Elsa Kania, observed to similar effect regarding the competition for dominance in artificial intelligence (AI) development specifically: "the real 'arms race' in [AI] is not military competition but the battle for talent."[2] This was a sentiment widely echoed by analysts, and applied broadly beyond AI to all fields of technological competition.[3]

From the 2010s China has increasingly shown signs of an advantage over its primary economic rival, the United States, in terms of the general education of its population and concentration of skills and talent among its citizens which was needed to compete in high tech. This could be measured in a number of ways including the number of patents being filed, the number of science and technology related papers being published and cited, and the performances of children in schools, with almost all metrics consistently pointing to a fast-growing Chinese edge. Taking as an example the number of peer-reviewed papers published in scientific journals, which is considered

the most basic barometer of a country's research and development activity, China overtook the US in the 2016–2018 period publishing 19.9 percent of the world's total at 305,927. This was 18 times the country's average for the 1996–1998, and 3.6 times that from the 2006–2008 period, with the rate of growth indicating that China would likely double the US figure before 2030.[4] Like in many metrics of technological competition, the two countries were very much in a league of their own, with third place held by Germany at just 67,041 papers—less than quarter of the US figure of 281,487 papers.[5] The fast growing number of Chinese publications came on the back of fast growth in its still developing economy, in research funding, in the proportion of its population working in research, and in the number and rankings of its institutions.

Looking to other metrics for a country's education level, China's lead was if anything greater still. The OECD Programme for International Student Assessments (PISA) test results published in 2019, based on a study of 600,000 children from across the world, found that Chinese students closely followed by those from Singapore were the best educated in the world and were several years ahead of their Western peers across the spectrum. The results were interpreted to portend a stronger economic performance for China in future.[6] PISA was widely held in high regard for assessing not knowledge which could be learned by rote, but rather fluency in problem solving and interpreting information, or "knowing how to think" as some experts described it.[7] Economists had found an almost one-to-one match between a country's PISA scores and its long-term economic growth, with the US expected to have seen GDP increase at the rate of one to two trillion dollars per year if it had scores comparable to those of China.[8]

The extent of the Chinese advantage by the mid-2010s often evoked responses of disbelief in the US and the wider Western world. This was the result of a combination of factors including the speed at which it was achieved, the way that China was portrayed in Western media, and the prevailing idea of Western supremacy which for centuries strongly influenced Western perceptions of the non-Western world. Prominent China expert and Director of Harvard Kennedy School's Belfer Center for Science and International Affairs, Graham Allison, observed in 2017 regarding American perceptions in relation to China's sudden educational advantage:

> For Americans who grew up in a world in which USA meant 'number one,' the idea that China could truly challenge the United States as a global educational leader seems impossible to imagine. This is not the only reality Americans wilfully ignore. In my national security course at Harvard, the lecture on China begins with a quiz. Students get a sheet with 25 indicators of economic performance. Their task is to estimate when China might overtake the United States as

> the top producer or market of automobiles, supercomputers, smartphones, and so on. Most are stunned to learn that China has already surpassed the United States on each of these metrics.
>
> I then ask whether they believe that in their lifetime China will overtake the United States to become the largest economy in the world. In last year's class of 60 students, about half bet they would live to see the United States become number two, while half disagreed. When I show the class headlines from the 2014 IMF-World Bank meeting announcing that China had become the largest economy in the world, students react with a mix of dismay and disbelief. By 2016, China's GDP was $21 trillion and America's was $18.5 trillion, when measured by purchasing power parity (PPP), which both the CIA and IMF agree is the best yardstick for comparing national economies.[9]

Allison emphasized that while China's economy grew three times as fast as that of the US, not only students but the country as a whole including most media outlets "missed the big picture" regarding its rise. He noted that as China overtook American fields across the spectrum of metrics, from research and development to leading engineering universities, it was imperative for US policymakers to begin to recognize and come to terms with "these uncomfortable but undeniable realities."[10]

Regarding the surprise with which China's growing primacy in high tech was being met in the West, Cambridge University Senior Research Fellow John Naughton observed that this was largely on the basis of decades old stereotype based on the idea of Western superiority. In a prominent 2013 article titled: 'China is after our inventions? Who are we kidding?,' he stated: "The idea that the Chinese are incapable of producing anything for themselves is an age-old racist argument." He argued that unfounded but widespread claims that China relied on theft from the West such as cyber espionage to advance were part of a broader trend toward 'yellow peril' influencing Western perceptions of the country, writing to this effect:

> this abusive hacking, so the Cassandras maintain, is intensely purposeful: its aim is to steal industrial secrets (intellectual property) from the west so that they may be used to give Chinese companies a market advantage . . . two things about the current hysteria about China bother me. The first is that it has echoes of earlier, semi-racist panics. The implicit assumption is that these oriental types are incapable of inventing stuff themselves, so in order to make economic progress they have to rip off the inventions of our clever chaps. They can't create, in other words, so they have to copy . . . the other puzzling aspect of the assumption [is] that the only way the Chinese can get on is by stealing from us.

Naughton countered these arguments, stating regarding his own experience with Chinese students in technical fields:

> One of the most striking aspects of the engineering and science departments of elite British and American universities is the astonishing numbers of Chinese students studying in them for postgraduate degrees. I've met quite a few of these students in the course of my day job. They are uniformly hard working and many are very smart indeed. Most plan to return home after they've obtained their degrees or completed their postdoctoral research. And anybody who thinks that they are intellectually inferior to their homegrown counterparts is not paying attention. . . . If China doesn't become a technological innovator, it won't be for lack of talent. There may come a time when we will need to steal from them.[11]

Broader comparisons between Northeast Asia and the US and Western world point to many of the same trends in discrepancies in education as those between China and the United States. Writing for the *Diplomat*, University of Texas Anthropology Professor John W. Traphagan highlighted that growing Chinese and East Asian primacy was largely based on cultural attitudes toward knowledge and education, which contrasted strongly with those he observed in America. He stated to this effect:

> It's not that there aren't dummies in East Asia, but it always seems that the average level of education and ability to think about the world intelligently and critically is impressively widespread. I've often thought about why this is the case and also why the same seems more difficult to say about the US The answer, I think, can be found in a comment science fiction writer Isaac Asimov made about the US while being interviewed in the 1980s: 'There is a cult of ignorance in the United States, and there has always been. The strain of anti-intellectualism has been a constant thread winding its way through our political and cultural life, nurtured by the false notion that democracy means that my ignorance is just as good as your knowledge.'[12]

Highlighting America's "cult of ignorance" as the greatest threat to the country's future, Traphagen contrasted this with competitors in East Asia where he was "always struck" by public intelligence. There prevailed "a culture in which rather than a cult of ignorance, a cult of intelligence plays a major role in shaping attitudes about the world and, thus, policies about dealing with other countries." He indicated that America's educational weakness was due primarily not to a flawed system, but rather something far more fundamental and difficult to address—a cultural difference. He stated to this effect: "The fundamental reason that countries in places like East Asia present such a significant challenge to the US politically and economically . . . is that these

countries have core cultural values that are more akin to a cult of intelligence and education than a cult of ignorance and anti-intellectualism . . . The problem is not really with our educational system; it is with our educational culture." As examples, he highlighted the contrast between how teachers in East Asia were "held in high esteem and normally viewed as among the most important members of a community," while "suspicion and even disdain" confronted their counterparts in the US.[13]

Trapenhagen's assessment were reflected in the contrast between China and the US in the kind of skills and professions valued. A Harris Poll survey in 2019 found that while children in China dreamed of space exploration, with an astronaut being the most popular profession of several given choices, those in the US and Britain overwhelmingly preferred to be entertainers—namely Youtubers or video bloggers.[14] Moreover, in sharp contrast to their status in much of the West,[15] in China tech and scientific workers were the highest paid in the country after overtaking finance professionals.[16] In the writer's own experience, attitudes toward educators and toward learning in Northeast Asia are indeed unique and contrast sharply with those in the Western world. Although the trends noted by Traphagen are more apparent in more traditional societies such as in North Korea, they cut across political lines in the region and are observable in South Korea, the Chinese mainland, Taiwan and Japan.[17]

Observations by American experts of the discrepancy between their own education system and those of East Asia, or China more specifically, were notably echoed in Britain. When visiting Chinese educational institutions in 2010 British Education Secretary Michael Gove was astonished by the difference in standards. He subsequently concluded "schools in the far east are turning out students who are working at an altogether higher level than our own."[18] The secretary's findings were widely supported by other accounts. The following year Oxford University's student paper observed to similar effect in an article on the experience of students returning from teaching in China: "Chinese students have a work ethic of dedication, resilience, and self-discipline, which quite frankly puts us—not only British students but also Oxford undergraduates—to shame."[19] These accounts mirrored findings from American educators who visited China. Margot Landman from the National Committee on US-China relations, for one, observed that not only were Chinese students "extraordinarily motivated to learn in ways that our kids aren't," but also that teachers were generally much better at feeding them information.[20]

Citing data from OECD PISA tests as an example, the BBC concluded in 2016: **"**China has shown the world that it is possible to simultaneously raise quantity and quality in schools . . . Perhaps tellingly, objections to the OECD's proposal for international comparisons between institutions of

higher education did not come from Asia, but from countries like the United Kingdom and the United States. Did they fear that their universities might not live up to their past reputations?" The tests cited showed that even the 10 percent most disadvantaged fifteen-year-olds in Shanghai scored higher in mathematics than the 10 percent most privileged fifteen-year-olds in the United States, and were far from isolated in pointing to this trend.[21]

The implications of the discrepancy in education between Northeast Asia and the West, and between China and the United States in particular, were very significant for their standings when competing in high tech. Prominent American theoretical physicist and bestselling author Professor Michio Kaku concluded based on his experience with the country's education system not only that the US institutions could not produce a high standard of graduates, but that the country was consequentially forced to rely very heavily on foreign talent for its scientific development. In a conversation with MIT research fellow Michael Schrage in 2016, Kaku stated:

> The weakness is precisely the educational system. The United States has the worst educational system known to science. Our graduates compete regularly at the level of third world countries. How come the scientific establishment of United States doesn't collapse? If we are producing a generation of dummies, if the stupid index of America keeps rising every year . . . America has a secret weapon. That secret weapon is the H-1B. Without the H-1B, the scientific establishment of this country would collapse. Forget about Google! Forget about Silicon Valley! There would be no Silicon Valley without the H-1B.[22] And you know what the H-1B is? It's the genius visa [a visa granted to foreign workers in specialty fields, often skilled tech workers]. You realize that in the United States 50% of all PhD. candidates are foreign born. At my institute, one of the biggest in the United States, 100% of PhD candidates are foreign born. The United States is a magnet sucking up all the brains of the world . . . There are no Americans who can take these jobs, these are at the highest level of high technology. They [foreign talent] don't take away jobs from Americans, they create entire industries.[23]

The importance of more educated talent from abroad to propping up America's tech sector and allowing it to compete internationally was widely alluded to by leading figures in academia and at various security think tanks.[24] Assessing the period from 1940 to 2000, a 2017 paper by the National Bureau of Economic Research found that immigrant innovators on average received significantly lower wages than their native-born counterparts, were more productive during their careers, and had a substantial positive macroeconomic impact through their contributions to American innovation.[25] Research analyst at Georgetown University's Centre for Security and Emerging Technology Tina Huang observed to this effect: "Historically the

US has relied on talent from elsewhere to fuel the country's technological dominance, and its key competitor nations are aware of this," stressing that any hindrance to America's access to foreign minds could seriously set back its tech sector.[26] Founder and former managing director of the International Strategic Alliances global advisory services firm, MIT PhD George Koo, noted to similar effect: "without the infusion of the best and brightest international students—and students from China make up more than one-third of them—elite schools such as the Massachusetts Institute of Technology would wither and shrivel if they had only America's own graduates, trained by a faltering K-12 system, to draw from."[27]

Taking artificial intelligence as an example of an emerging technology field of strategic importance, reports from 2019 showed that two-thirds of graduate students in American AI-related programs came from abroad with the number of domestic graduate students seeing no increase since 1990. US universities graduated around 50,000 international graduate students in AI-related fields per year. This underlined that with so few Americans having higher education in the field, the US could only hope to be a leading competitor in AI by incentivising international students gaining PhDs in the field in the US to choose to stay in the country. In this, however, it was highly successful, with almost 90 percent choosing to stay and over 80 percent staying for five years or more—many of whom came from American economic rivals including China. Furthermore, as of 2019, the large majority of those leaving went to US-aligned countries such as Britain, Canada and South Korea with less than 20 percent of those leaving going to China. As observed in a study from Georgetown University's Walsh School of Foreign Service, Centre for Security and Emerging Technology: "International graduates fill critical AI talent gaps in the US labor market. Objective labor market indicators and expert assessments suggest demand for AI talent will far outstrip supply for the foreseeable future."[28] Were access to large amounts of foreign talent lost it would likely end America's ability to compete in AI, with the Georgetown study warning:

> In the past, the United States could rely on its status as the world's sole science and technology superpower to compensate for the flaws of its immigration system, but in today's more competitive world, complacency is likely to come at a higher cost . . . The United States has lost its historical near-monopoly on AI R&D and commercial activity. In 2013, the United States accounted for more than 70 percent of funding deals for AI startups. By 2018, this number had dropped to 40 percent.[29]

The situation in AI reflected much broader trends across key fields in high tech, with the Georgetown study repeating the consensus view that America's

ability to compete very heavily depended on its ability to attract and retain foreign talent due to major domestic shortages.[30] Prominent American political scientist and W.H. Brady Scholar at the American Enterprise Institute, Charles Murray, observed in May 2021 regarding what was increasingly seen to be the country's best chance of competing with East Asian rivals technologically: "I've been saying it for years. Don't worry about China. Our Chinese will beat their Chinese." This was a comment on America's victory over China at the International Maths Olympiad—a competition in which China held the most victories by a considerable margin since its foundation—using a team entirely comprised of Americans of Chinese origin.[31]

Students from Northeast Asia in particular not only propped up American science and R&D, but also played a vital role in financially supporting American academic and research institutions particularly after the 2008 financial crisis. *Bloomberg* columnist and former editorial director of *Harvard Business Review*, Justin Fox, wrote regarding the importance of Chinese students in particular: "when it comes to American colleges and universities, I really don't know how many of them could survive without foreign students in general and Chinese students in particular. The flow of money from foreign students has become so big that it even has some impact on the overall economy."[32] A 2020 study by Georgetown University found mainland Chinese nationals accounted for 16 percent of all foreign undergraduates studying science, technology, engineering or mathematics in the US, with his figure being even greater at the postgraduate level.[33]

While a tech industry reliant on a diverse and international talent base had considerable benefits for innovation, extreme reliance and the lack of a robust domestic talent base raised significant questions regarding the sustainability of America's position in high tech. This was largely due the vulnerability and potential fragility caused such dependence, due to the significant possibility that America's access to foreign talent could be undermined. Changes to the status of the US dollar, decline in American soft power or emergence of more attractive tech hubs overseas, were among the possibilities that left the US tech sector more vulnerable than those which could rely on domestic talent.

LOSING EAST ASIAN TALENT: PROJECTING FURTHER DECLINE FOR WESTERN RESEARCH AND EDUCATION

With China already having significant and growing advantages in its general education and R&D, its ability to outcompete the US technologically is expected to be further strengthened as the vital support given to the US and Western education and tech sectors by Chinese and Northeast Asian students is undermined. Multiple cumulative factors have increasingly begun to

undermine the appeal of work and study in the West to East Asian talent, and even to Westerners of East Asian origin. These include growing hate crimes targeting East Asians, discrimination from authorities in Western countries, more restrictive visa policies, economic downturn in the West, perceptions of the West as unsafe based on its handling of the COVID-19 pandemic, and growing opportunities outside the Western world including in China itself.

The growing number of hate crimes targeting ethnic East Asians across the Western world only worsened as China was increasingly portrayed as a threat to Western primacy and prosperity in Western media from the mid-2010s.[34] This followed previous less extreme waves of hate crimes in the 1940s and 1980s coinciding with periods where Japan was portrayed as a threat to the West, the former after the Second World War's oubreak and the latter due to its economic growth.[35] Taking Britain as an example, a 2017 survey found that close to half of Chinese students were subjected to racial discrimination, with rates of serious crimes targeting the community being particularly high.[36] Reports of serious physical attacks on scholars of Chinese origin increased drastically in the wake of the COVID-19 crisis,[37] with media coverage of China in general, and particularly of the pandemic which consistently blamed Beijing, being a major cause.[38] This represented part of a much broader trend which also strongly affected the US,[39] Australia,[40] and the wider Western—what was then referred to by some as a 'moral pandemic' of anti-Asian hate.[41] With the US having a longer history with a sizeable East Asian minority, there was also a particularly long history of scapegoating this minority.[42] Racially motivated attacks notably targeted women and the elderly of East Asian origin at particularly high rates from 2020.[43]

The way portrayals of China as a threat to the West fueled mistreatment of East Asians was far from unprecedented. Chinese American writer Nina Kuo observed regarding this phenomenon in an article for the *New Republic* in May 2021: "long before [US President Donald] Trump took office, xenophobia, anti-Asian racism, and Yellow Peril–style propaganda served as useful tools to advance American domestic and foreign policy goals . . . Who we define as our international enemy, or perhaps just competitor, also becomes our enemy at home." East Asians were increasingly portrayed as "The Yellow Peril, the faceless horde, the ever-growing yellow population, an existential threat to the West, to liberal human rights, to the market economy, to the 'rules-based' order, to American primacy." Regarding the consequences for Asians in the West, she noted: "When the US is in conflict with another nation, that nation's diaspora becomes the target of state suspicion and violence here . . . we Asian American and Pacific Islanders can expect an increase in surveillance, harassment, and attacks."[44]

Kuo's assessment reflected a much broader consensus view which had multiple historical precedents, and which the spike in racially motivated

attacks from 2020 strongly supported. With such an environment expected only to worsen as China's power and its challenge to Western primacy grew, arguments were strengthened for people of East Asian origin to avoid the Western world and the US in particular.[45] As multiple sources were highlighting by 2021, even US-born Asian Americans who faced language and culture barriers when emigrating were looking to move to East Asia to escape discrimination, abuse and social problems. The discrepancies in handling of the COVID-19 pandemic furthered the attraction of a 'return to Asia' and shook many people's faith in their safety in the US, as did other factors ranging from mass shootings to a fragile healthcare system.[46] Growing perceptions of better job opportunities in Asia was another important factor.[47]

The trend toward the West's shrinking appeal for work or study was exacerbated by the COVID-19 crisis due not only to rising hate crimes and anti-Chinese sentiments,[48] but also because the West's underwhelming response to the outbreak strongly influenced Chinese perceptions of the safety of Western countries. As the *New York Times* highlighted in a March 2020 report, Western countries' underwhelming responses to the pandemic had caused serious concerns among Chinese students, left many "fuming" over perceived ineptness compared to the responses seen across Northeast Asia, and diminished both the appeal of study in the West and attitudes to Western countries more generally. According to the *Times* these factors, and the fact that East Asian students were increasingly seriously concerned for their own safety, were likely to have implications long after the pandemic and potentially devastate the finances of the higher education sectors in multiple Western countries.[49] The paper noted to this effect:

> With qualifying exams postponed, travel bans spreading and anger rising among Chinese students and parents at the West's permissive attitude toward public health, enrolment could plummet in the coming years, experts said, potentially leaving countries with multibillion-dollar holes in their universities' budgets. Already, analysts are talking about the prospect of government bailouts of higher education if Chinese students stay home, starving universities of the often-exorbitant overseas tuition fees that keep their less-profitable departments afloat.[50]

Another factor which long preceded COVID-19, and accompanied rising hate speech and hate crimes from the general public, was the growing suspicion and discrimination both Chinese citizens and Americans of Chinese origin faced in the US from the government itself. In June 2019, for example, it was reported that the FBI was openly urging universities to assist it in spying on Chinese students and on scholars from Chinese institutions. FBI officials visited major universities and instructed on how students and scholars should

be monitored, according to three administrators at three of the universities interviewed by *NPR*. Indiana University vice president of research Fred Cate told *NPR* regarding this: "It's not a question of just looking for suspicious behaviour—it's actually really targeting specific countries and the people from those countries." He highlighted that FBI agents were interested in learning which labs Chinese students were working with and what information they were being exposed to.[51]

An increasingly hostile political climate for Chinese students seriously undermined the appeal of studying, researching or working in the West.[52] Calls in the US to ban Chinese students from studying science or technology related subjects, on the basis that they would return to their countries with expertise needed to challenge America's own tech sector, threatened to worsen the situation considerably.[53] American lawmakers notably submitted a bill to this effect in May 2020—the Secure Campus Act—which had the potential to be the first of many similar restrictions as an increasingly Sinophobic atmosphere[54] pervaded.[55]

One of the many consequences of the changing political climate was an increase in searches of Chinese nationals' electronic devices at customs with a year-on-year increase of 66 percent in 2019 alone.[56] Moves announced in September 2020 by the Department of Homeland Security to revoke the visas of large numbers of Chinese students, although criticized by many in Washington for "singling out Chinese students with visa restrictions" and undermining America's reputation among international students, led to a growing sense that Chinese at US institutions were being closely observed.[57] In October 2020 the Chinese Foreign Ministry alleged that American authorities "wantonly harass and interrogate Chinese students, and even arrest and prosecute them under false allegations." It claimed that airport officials "arbitrarily examined and even seized" phones, laptops and other personal belongings.[58] A prior statement from the Chinese embassy in July warned of "a sharp increase in cases in which the US law enforcement agencies carried out random investigations, nuisance or confiscation of personal belongings against Chinese students in the US."[59]

The report in May 2021 that a Chinese student was denied a visa, on the sole basis that their father was a low-level police officer and thus connected with the Chinese state, showed how extensive restrictions were becoming.[60] Four months later there was an outcry in Chinese media as a student was held arbitrarily with little food for fifty hours, and subsequently deported without evidence against him being presented.[61] This kind of conduct led to allegations of racial profiling fueled by growing Sinophobic sentiments.[62] Americans of Chinese origin, too, were increasingly targeted by the FBI for investigation and surveillance, indicating that growing suspicions were indeed constructed on the basis of race rather than nationality.[63] This brought

about the risk not only of pushing Chinese citizens vital to the US tech sector away, but also of pushing away[64] Americans of East Asian origin who played a disproportionately important role in the sector.[65]

ASIAN TALENT LOST AND ITS IMPLICATIONS FOR US AND WESTERN HIGH TECH

Bloomberg drew attention to the potential dangers of alienating East Asian talent in a prominent 2019 article titled: 'US Targeting of Chinese Scientists Fuels a Brain Drain.' It highlighted as an example the case of a Chinese scientist with a key nanotechnology startup being forced to quickly leave the US after enduring unfounded searches, airport stops and a failed sting from the authorities. Award-winning tech entrepreneur Dr. Xin Zhao had obtained venture funding to commercialize patented nanotechnology from the College of William & Mary, with his startup hiring local graduates and agreeing to fund $1 million of new research at the university. He had won the top energy prize from the prominent innovation group the World Technology Network for developing the graphene supercapacitor—a potentially revolutionary paper-thin sheet of nanomaterial that could store hundreds of times more energy than conventional lithium-ion batteries and could charge in just seconds.

Bloomberg described a grueling ordeal after Zhao was hounded by federal agents for two years and accused by prosecutors of espionage for China. This included having his computers seized by American federal agents under the pretext of searching for prohibited pornographic material—a commonly used pretext according to Zhao's lawyer who covered several similar cases for residents of East Asian origin. Legal fees after Zhao's arrest, and following a setup by federal agents, reached $110,000. According to his lawyer the case was pursued largely due to the political atmosphere in the country, because "these kinds of cases involving Chinese living in the US are a high priority for the government." Despite the allegations later being officially dismissed, the unfounded attacks on Zhao had tarnished his name and seriously undermined the appeal of pursuing the startup in an increasingly hostile and Sinophobic climate. His company's R&D and new patent registrations, which were extremely valuable to any new high tech startup, went to China with him. "Fear is pushing us back to China," Zhao concluded as a result of experiences in the US, stressing that he had lost faith in the American legal system and didn't want to put himself or his staff at risk by operating there.[66]

Bloomberg observed regarding this trend: "America's heightening cold war with China presents risks for ethnic Chinese scientists working in the US. He's among a growing number who are leaving behind their families

and taking their skills and business opportunities to—where else?—China." Highlighting that this represented part of a much broader and very dangerous trend, it concluded:

> a significant brain drain of Chinese experts could decimate many of America's most celebrated enterprises. Inventors with Chinese last names account for one out of every 10 new patents in the US today . . . While China lost more than 50,000 inventors to emigration from 2002 to 2011, the US welcomed a net gain of more than 190,000, as measured by patent registrations, according to data compiled by the World Intellectual Property Organization. [67]

This phenomenon was referred to by a number of sources such as Singapore's *Straits Times*[68] and China's *CGTN*[69] as 'reverse brain drain,' and had the potential to seriously undermine the American tech sector's ability to compete. Law professor at U.C. Hastings in San Francisco Frank Wu presented the nature of the situation particularly eloquently stating: "The joke in Silicon Valley is that if the feds, in the name of protecting intellectual property, deter Chinese researchers from working in the US, there won't be any intellectual property to protect."[70] Former federal government statistician Jeremy Wu similarly observed that Zhao's case exemplified a wider emerging trend among targeted Chinese scientists and engineers. "The net effect is we're pushing top talent away," he warned.[71] As highlighted by the *South China Morning Post*: "China's talent is turning away from multinationals and toward domestic tech champions in the search for a more fulfilling career. Change in sentiment comes amid raging US-China tech war and perceptions of 'bamboo ceiling' in the West [a term for lower social mobility for ethnic East Asians due to racial discrimination]." The post gave multiple examples of much valued experts who, for a variety of reasons ranging from a better work atmosphere and lower discrimination to the growing dynamism of Chinese startups, were choosing China over the West.[72] This trend affected both American firms and academic institutions, with a fast-growing number of international students declining admission offers to US universities because they preferred to study at home or in other countries. The figure grew threefold between 2016 and 2018 alone.[73]

Harvard Business School professor William Kerr, an expert on the subject of America's attraction of overseas talent and 'brain drain,' warned in 2019: "Beyond just their own inventions, ethnic Chinese are integrated throughout our whole scientific establishment, including startups . . . If you damage that ecosystem, it's going to harm a lot of very productive relationships that will be hard to rebuild."[74] Nobel Prize–winning physicist at Stanford University and former secretary of energy under the Obama administration, Steven Chu, noted in late 2020 that "there are certainly people leaving," citing examples

of valued experts of East Asian origin who departed due to the unfriendly environment in America that resulted from negative media portrayals of and political tensions with China. "I'm trying to convince these people not to go back. If it wasn't for immigrant scientists, we would be a second-tier STEM [Science, Technology, Engineering and Mathematics] country," he said, noting that China offered many promising opportunities to attract talent.[75] Tao Ning, president and partner of Sinovation Ventures, a leading Chinese venture capital business focused on AI, stated to similar effect regarding the opportunity this presented China: "while the US is driving talent away, it is the perfect time for us to race to bring them back."[76] The Chinese government from 2021 increasingly indicated a strong interest in drawing tech talent from abroad with overseas Chinese minorities having long been among the most likely groups to consider work in the country.[77]

American immigration lawyer Jessica Chen was among the many who stressed that the treatment of Chinese scholars in particular created a fearful atmosphere and made them more prone to leaving. Singling out of these scholars by ethnicity, including allegations of spying, "creates a truly oppressive environment in which to try to perform research," she noted. An investigation by *Nature* magazine in September 2020 found that the exodus was happening on a significant scale and included both scientists who were Chinese nationals as well as Chinese Americans. It also found that American researchers of Chinese ethnic origin were increasingly seeking legal advice because they feared being targeted—they were "worried their lives will be ruined for no good reason" in the words of the president of Queen's College in New York Frank Wu.[78] Former federal prosecutor Peter Zeidenberg, a leading defense lawyer for Chinese researchers targeted in cases similar to that of Zhao, likewise warned regarding government policies: "By cracking down so aggressively, we're pushing them into China's arms." The rate at which Zeidenberg's researcher clients were returning to China as a result of US government actions, or otherwise considering going back, was very significant, with some being leading or even world-renowned experts in their fields.[79]

One prominent case was that of the husband-and-wife team of Chinese American neuroscientists Li Shihua and Li Xiao Jiang, who were forced to abandon their cutting-edge research at Emory University in Atlanta for allegedly failing to disclose all of their research relationships in China. Their laboratory at Emory with fifteen researchers focused on neurodegenerative disorders such as Alzheimer's disease. Director of neurobiology at Johns Hopkins University School of Medicine Christopher Ross, who collaborated on several papers with the couple, stated that relocation of their research away from the US was "a substantial loss." "Everyone knew I was working in China," he stressed, warning that the move to seize their data and devices and close their lab based on the sole allegation of failing to fully disclose

their China ties was "highly disproportionate and raises questions about university procedures and academic freedom."[80] Neuroscientist at Thomas Jefferson University in Philadelphia, Diane Merry, said that the couple would be sorely missed due to the exceptional nature of their scholarship after being effectively driven out. "Doctors Li and Li helped shape the field through their engagement and support of other scientists, providing critical thinking and judgment to guide future research . . . Their commitment to finding a cure for these diseases is unparalleled," she lamented.[81]

Complementing the diminishing attraction of study or research in the US and the West was China's extensive investment in improving its own higher education, bringing more of its institutions to the level of leading international contenders.[82] One of the most widely noticed indicators of this was when China's Tsinghua University dethroned MIT as the top engineering university in the world in 2015—according to the closely-watched annual rankings from the *US News & World Report*. Director of Harvard Kennedy School's Belfer Centre for Science and International Affairs, Graham Allison, observed in 2017 regarding this development and what it signified:

> Tsinghua's recent surge is not an isolated example. Everyone knows about China's rise, but few have realized its magnitude or its consequences. Among the top 10 schools of engineering, China and the United States now each have four. In STEM subjects (science, technology, engineering, and mathematics), which provide the core competencies driving advances in the fastest-growing sectors of modern economies, China annually graduates four times as many students as the United States (1.3 million vs. 300,000). And in every year of the Obama administration, Chinese universities awarded more PhDs in STEM fields than American universities . . . A nation that did not appear in any of the international league tables in 1980 has vaulted into the top position. Yet in the face of what is arguably the most consequential geopolitical trend of our lifetime, Washington has mostly played a game of 'let's pretend.' Policy makers have repeatedly put forward strategies to 'manage' China. The question we should ask candidly is whether China has been managing us.[83]

Improvements in China were not only qualitative, but quantitative as well. An August 2021 report by Georgetown University's Centre for Security and Emerging Technology highlighted that Chinese universities were graduating approximately three STEM PhDs for every two graduated by US universities, with this 50 percent lead set to double to around 100 percent by 2025. "Given the scale of China's investments in higher education and the high-stakes technology competition between the United States and China, the gap in STEM PhD production could undermine US long-term economic and national security," it stressed. The report highlighted that this growth was occurring in parallel to a rise in the quality of doctoral education in China, and that the

speed at which it was occurring was unprecedented with US universities having awarded twice as many doctorates in STEM fields as Chinese universities in 2000 only to be matched and overtaken just seven years later.[84]

One of the report's authors, Jack Corrigan, observed regarding the implications of these findings: "We are living in a world where a country's economic and national security is increasingly dependent on its ability to develop and utilize advanced technology in areas like artificial intelligence, synthetic biology, quantum computing—all of the big emerging technologies. And in order to develop and deploy those technologies, countries need to have access to a large, knowledgeable and well-trained pool of STEM talent." Between 2003 and 2007 the number of annual STEM PhD graduates in China more than doubled, while between 2016 and 2019, the number of students entering STEM doctoral programmes at Chinese universities increased nearly 40 percent, from 59,670 to 83,134. The bulk of growth in Chinese STEM PhD enrolments came from higher ranked universities, with a little under half coming from China's top-level 'Double First Class' universities while around 80 percent came from universities administered by national ministries. These had a much higher quality on average than locally or privately administered universities which graduated only 20 percent of STEM PhDs. This trend was seen to be vital to driving China's rise as a leading innovator in high tech.[85]

Chinese R&D benefitted considerably from 'reverse brain drain' as experts returned home from the Western world in growing numbers, as the *Straits Times* highlighted even before COVID-19 in 2019:

> [Silicon] Valley's bright lights are being increasingly drowned out by mainland China's tech hubs, such as Shenzhen and Beijing. This is helping transform the brain drain into a brain gain, as many Chinese people working overseas return and help embed their expertise in local businesses and academic institutes or launch their own startups. These strong opportunities are a direct result of government policy which has for years encouraged direct investment in areas such education and technology infrastructure, while setting clear supporting policy goals, such as becoming a global hub for artificial intelligence. This helped foster a vibrant technology ecosystem which has built on the success of China's tech giants and entrepreneurs, including Alibaba's Jack Ma and Huawei. . . . Once the best Chinese scientists would seek research work overseas, but today Chinese postdoctoral researchers often get experience in the West and then head home where the Chinese government helps set them up in world-class facilities. The power of China's public and private sectors working together for the same purpose has been so successful that other countries have been called on to emulate it.[86]

Bloomberg referred to this trend as "an exodus triggered by abundant capital, growing innovation and flourishing career opportunities," noting that there

were "growing ranks of successful Silicon Valley alumni lured back to China by the promise of a brighter future." It highlighted:

> an unprecedented trend with disquieting implications for Valley stalwarts from Facebook Inc. to Alphabet Inc.'s Google. US-trained Chinese-born talent is becoming a key force in driving Chinese companies' global expansion and the country's efforts to dominate next-generation technologies like artificial intelligence and machine learning. Where college graduates once coveted a prestigious overseas job and foreign citizenship, many today gravitate toward career opportunities at home, where venture capital is now plentiful and the government dangles financial incentives for cutting-edge research.[87]

Although before COVID-19 America's tech sector was gaining considerably more than China's own from Chinese students and professionals in the US, with the majority not quickly returning home, this had the potential to change very quickly in the 2020s. The *Bloomberg* report noted that a further key driver for Chinese experts to return was that the formerly unparalleled prestige conferred by working for US tech giants had now been matched by the benefits of working for emerging Chinese giants such as Tencent, Toutiao and Baidu. It highlighted that Alibaba and Tencent now ranked among the world's most valuable companies, and that three of the world's five most valuable startups were based in Beijing.[88] This was also an important factor in Chinese efforts to recruit Japanese, European and Canadian specialists such as software developers and chip engineers.[89]

Managing partner at venture firm GGV Hans Tung, who organized events to recruit talent to work in China, stated regarding recruitment efforts: "More and more Chinese engineers who have worked in Silicon Valley for an extended period of time end up finding it's much more lucrative for them career-wise to join a fast-rising Chinese company . . . At Google, at LinkedIn, at Uber, at AirBnB, they all have Chinese engineers who are trying to figure out 'should I stay, or should I go back.'" Headhunter for the Spencer Stuart leadership consulting firm and leader of its technology practice, Ken Qi, noted regarding the growing trend toward Chinese talent returning home and depriving the American tech sector: "More and more talent is moving over because China is really getting momentum in the innovation area . . . This is only the beginning."[90] The US National Security Commission on Artificial Intelligence warned to similar effect in 2018: "For the first time in our lifetime, the United States risks losing the competition for talent on the scientific frontiers."[91]

Tech was notably found in 2017 to have supplanted finance as the field in which most Chinese returnees entered into. The increase was a steep one, with the proportion going into the tech sector rising from around 5.5 to

15.5 percent from 2015 to 2017 alone and the number of graduates returning to China from the US rising 22 percent from 2013 to 2017 to reach 432,500.[92] With this trend expected to continue accelerating in the 2020s, the implications in terms of both a boost to Chinese tech and an undermining of the American tech sector are tremendous. In Artificial Intelligence, for example, 7.9 percent of America's over 850,000 AI engineers were Chinese as of 2017.[93]

The fast-diminishing attraction of higher education and work in the West has the potential to strip Western economies of East Asian talent vital to propping up their tech sectors.[94] Even before COVID-19, amid rising anti-Chinese sentiments and tensions surrounding the fallout from the Obama administration's Pivot to Asia and its successor's Trade War, the number of Chinese students remaining in the West after study was declining sharply. From 2000 to 2017 the number of Chinese overseas students returning home rose from just 10 percent to 80 percent, with 2010 being a tipping point when over 50 percent began to return.[95] The figure was set to continue to increase throughout the 2020s. A number of factors beyond political and racial tensions were responsible including the closing of the gap in living standards between major cities in China and the West and the growing dynamism and sophistication of the Chinese economy which made it much more attractive to the country's educated graduates.[96]

Western assessments continued to confirm this trend. A November 2017 report by the All-Party Parliamentary Chinese in Britain Group presented findings that that 90 percent of Chinese students in the United Kingdom would prefer to look elsewhere to study due to poor conditions in the country. The study further found that Chinese students made up 30 percent of the country's total international students, and stressed the importance of their contribution to the British economy.[97] The situation only worsened from 2020, a notable example being that police data showed hate crimes against East Asians in the first quarter of 2020 were 400 percent what they had been the previous year.[98]

Beyond support for high tech, Western economies depended heavily on support from Chinese students' spending power.[99] In the US, according to figures from the Association of International Educators, three US jobs were created or supported for every seven international students enrolling in the country.[100] As a headline from *CNN* highlighted in November 2019, the economy was "losing billions of dollars because foreign students aren't enrolling," with concerns regarding their safety in America being a major cause for hesitancy to enrol.[101] As by far the largest group of foreign students, Chinese students still spent $15 billion in tuition payments alone in 2019 with their diminishing numbers expected to harm the wider economy and force up tuition fees for American students.[102] Some American universities lost over

a quarter of their revenue while the US economy as a whole by the end of 2019 had lost $11.8 billion and more than 65,000 jobs as a result of reduced enrolment.[103]

More importantly than economic losses, however, American tech firms' heavy reliance on Chinese students for recruitment meant their declining numbers could seriously threaten its access to foreign talent. Workers who entered as university students tended to remain longer and integrate better than those who first entered through temporary employment visas.[104] Thus both a decline in the domestic economy and education sector, as well as loss of a foreign talent pool vital to propping up the American tech sector, were both at stake with potentially serious implications for US competitiveness in high tech.

CLIMBING TO THE TOP OF GLOBAL SUPPLY CHAINS

While in the immediate post-Cold War years the United States was effectively in a league of its own in science and engineering (S&E), it became increasingly clear by the mid-2010s that this had changed drastically as competitors outside the Western world, and China in particular, invested in their own tech sectors while America's began to decline. A State of US Science and Engineering 2020 report, a biannual federal report published by the National Science Board and the National Science Foundation and submitted to Congress, carried dire warnings to this effect, with National Science Board chair Diane Souvaine warning: "where once the US was the uncontested leader in S&E, we now are playing a less-dominant role in many areas." A decrease in federal funding was cited as a factor contributing to America falling behind its competition, with China by itself having contributed nearly a third of all global R&D growth since 2000.[105]

Federal funding for research and development had been in slow decline since the Reagan administration, and fell as a percentage of gross domestic product from 1.23 percent in 1976 to 0.71 percent in 2020.[106] The potential implications were particularly dire, with the chair of the National Science Board's science and engineering policy committee Julia Phillips stating regarding the importance of this funding: "Federal support of basic research drives innovation. Only the federal government can make a strategic, long-term commitment to creating new knowledge to lead to new or improved technologies, goods or services. Basic research is the 'seed corn' of our US S&E enterprise, a global competitive advantage, and the starting point for much of our GDP growth since World War II."[107]

The Science Foundation's report to congress noted that the US' share of global research and development had declined to 25 percent, and according

to its figures the gap R&D expenditures between East and Southeast Asia and the Western world had narrowed considerably. As of 2017 the US and EU together made up 45 percent, while the Western Pacific region made up 42 percent. The gap only continued to narrow with Asian growth overwhelmingly fueled by China. It is important to note that this did not take into account the vast discrepancy in purchasing power between Western economies and those in Asia, which would otherwise show the latter to be investing considerably more in real terms in R&D. A lot more research could be done for every million dollars spent in China than it could in the West, with costs ranging from cleaning labs to purchasing equipment and paying researchers all being far lower.[108]

According to a 2019 report issued by the Carnegie Endowment for International Peace: "China has eclipsed the US as the world's largest overall (public and private) R&D investor."[109] It pointed to the Chinese government's intramural funding in 2017 of $64.4 billion, compared to $47.1 billion in the US.[110] In 2020, China's total R&D spending reached to 2.4 trillion yuan, from around 1.42 trillion yuan in 2015, meaning it had grown by 69 percent in just five years.[111] An extreme focus on R&D was seen in both the private sector, most famously from telecoms giant Huawei which exemplified a wider trend, as well as in the public sector.

Regarding China's growing R&D advantage a February 2020 National Defense Industrial Association report highlighted: "In 2017, federal R&D spending as a share of the gross domestic product fell to its lowest level since 1955 . . . Comparatively, China's public sector investment in R&D increased by 50 percent between 2011 and 2016. Unsurprisingly, Chinese entities now file nearly 50 percent of all patent applications submitted worldwide."[112] This proportion of global patent applications reflected a very rapid rate of growth, with Chinese entities having had just 40 percent two years prior in 2018 (1.38 million of 3.17 million). This was already over double that of the United States (607,000) and over four times larger than of Japan (318,000), with the runners up South Korea (205,000) and the EU (167,000) lagging far behind.[113] Referring to Intellectual Property (IP) backed innovation as "an increasingly critical component of competition and commercial activity," World IP Organisation Director-General Francis Gurry stated in 2018 regarding China's strong performance and rapid growth: "In just a few decades, China has constructed an IP system, encouraged homegrown innovation, joined the ranks of the world's IP leaders—and is now driving worldwide growth in IP filings."[114] This set a trend for a large majority of the world's patent applications to be filed from China by 2030.

A 2020 report by the influential China Strategy Group (CSG) think tank, titled 'Asymmetric Competition: A Strategy for China & Technology,' highlighted "long-term neglect of our R&D base, atrophy of federal funding,

and insufficient response to the China challenge." The report stressed that in key areas such as artificial intelligence, nuclear fusion, quantum computing and autonomous vehicles, China had major competitive advantages due to factors such as its greater domestic market scale, flexible regulatory environment and faster product integration loop.[115] The report was first publicized in January 2021, and was highly supportive of the need to wage a 'tech war' on China,[116] undermine Chinese economic modernization and ensure continued US and Western primacy in high tech.[117]

China's focus on R&D in both the private and public sectors increased sharply from the late 2010s due to two primary factors. The first was that technologies which experienced discontinuous development such as artificial intelligence, quantum computing and 5G were projected to automate traditional manufacturing and industrial practices to unprecedented degrees, providing greater interconnection and information transparency. The significance of this development was reflected in its name—the 'Fourth Industrial Revolution.' These technologies were expected to provide very major and long-lasting economic advantages to first movers—advantages that parties which lagged at the beginning could find extremely difficult to compensate for later on. As Senior Fellow James L. Schoff observed in a paper for the Carnegie Endowment for International Peace think tank:

> Profitability and mastery of next generation technologies under development today could be much narrower. In the past, while it is true that initial inventors and the most successful application designers reaped outsized rewards, the playing field for these products levelled over time and other countries' firms were able to compete successfully . . . In the emerging digital era, however, it is possible that early data monopolies combined with mastery of AI and quantum computing could quickly dominate certain markets and make international competition prohibitive. [118]

The importance of gaining a lead as quickly as possible in the development of these new technologies could not be overstated. As one example of a key first mover advantage, Schoff noted: "challenge to firms in US and allied countries would be exacerbated if Chinese technological standards in these emerging fields become widely adopted around the world. This is true not only in the context of ancillary product compatibility—such as apps designed to work only with Chinese platforms—but also in terms of complementary support systems and practices in such areas as data privacy, data localization, and cloud sourcing." The same applied vice versa for Chinese firms should the US gain a lead and American or Western standards be widely adopted. Regarding their importance, he stressed: "Breakthroughs in these fields can potentially shift the future balance of economic and military power,

prompting governments and large corporations to compete aggressively now over their development and applications."[119]

The second cause for China's renewed focus on R&D was growing pressure from the United States. This first came under the Barack Obama administration which sought to focus foreign policy and military attentions on Beijing from the early 2010s,[120] and subsequently under the Trump administration, which escalated rhetoric sharply and expanded the scope of conflict deeply into the technology and economic spheres. Washington's tech war provided a very clear incentive for Chinese industry to move in on the top of vital value chains and thereby secure itself against attack, as perhaps most clearly demonstrated by the campaign leveraging global chipmakers' reliance on American software to target the telecoms giant Huawei (see chapter five).

In part to increase security against possible Western economic attacks, the Chinese government supported the drive by local tech companies to move up value chains and reduce or eliminate reliance on high tech inputs from the US and from parties potentially susceptible to its pressure such as firms in Japan, South Korea and Taiwan.[121] The fact that Beijing would emphasize securing supply chains was anticipated by some even before the tech war and the attacks on Huawei, with Renmin University economics professor Liu Rui stating to this effect in the wake of US restrictions on Chinese exports in 2018: "And the trade war has also hardened China's resolve. The initial result of the trade war has made China appear to be weaker . . . But it is precisely this weaker position that has awakened China, forcing us to change our approach."[122] While previously the US had led ideation, research and development, and execution in high-tech, from the mid-2010s it became a key objective for Beijing to move Chinese industry quickly up major value chains to challenge American dominance of key technology areas.

CHINESE INNOVATION: THE KEY TO A TECH WAR VICTORY?

On October 30, 2020, the central committee of China's ruling Communist Party announced that the country's fourteenth five-year development blueprint would be drafted as part of efforts to "accelerate the building of a science and technology power." "Science and technology should be self-reliant as a strategic support for national development," according to the statement, with the plan promising a seven percent annual increase in R&D investment and naming semiconductors, artificial intelligence and quantum computing as "fundamental core areas" for development. Five-Year Plans had been a cornerstone of socialist development across four continents since the 1920s, and had been pursued in China since 1950. Despite the growth of its private

sector since the 1980s, state planning still played a very major role in shaping the course of the country's economic development. The party's October statement highlighted a "complicated international situation," in what was widely seen as a reference to growing American pressure including economic warfare efforts, as well as environmental protection goals and the need for "green and low-carbon development." These were the primary factors that would shape state priorities for economic[123] modernisation.[124]

Regarding the new Five-Year Plan Shanghai-based chief economist at the Hang Seng Bank, Dan Wang, predicted in October 2020: "One thing I think will stand out is the supply chain security. I think there will be some major adjustments because this Fourteenth Five-Year Plan is a long-term plan. It's not an emergency plan. It will drive some of the long-term issues. Now with some of the US competition, there will be a lot of stress on strengthening those sectors related to national security and basic livelihood of people."[125] Founder of the YaSong Institute of City Strategy, Qin Gang, noted to similar effect that month that the plan was "primarily overall to satisfy China's domestic demand." "The Fourteenth Five-Year Plan isn't just about the next five years, but the next thirty years," he stated regarding its long-term importance.[126]

Chief researcher at the Bank of China, Zong Liang, predicted in October that the plan's focus on boosting high tech could come at the expense of economic growth, stating: "In the next five years, China will really emphasize high-quality growth, so the speed might not be as great as before." He stressed that the coming half decade could be decisive in allowing China to escape the so-called 'middle-income trap' by moving its economy up the value chain.[127] This economic theory was defined in an Asian Development Bank Institute paper as a phase in which a middle-income country "can no longer compete internationally in standardized, labor-intensive goods because wages are relatively too high, but it also cannot compete in higher value-added activities on a broad enough scale because productivity is relatively too low." The key determinant in whether China's economy would be stuck at the middle-income level or surpass it was innovation quickly, effectively and on a large enough scale to sustain increases in both wages and growth opportunities. The paper was fittingly titled on this basis: 'Escaping the Middle Income Trap: Innovate or Perish.' "Insufficient development of domestic innovation capabilities is at the heart of the middle income trap," it stressed, although the conditions for countries to fall into this such as neglect for R&D investment strongly indicated that the 'trap' was unlikely to be a major issue for China.[128]

While capacity for innovation has been sorely lacking in regions such as Latin America,[129] which was the textbook example of the Middle-Income Trap, China's position was entirely different and, despite the considerable Western pressure placed on its economy, remained far stronger. With a strong

middle class being a major driver not only of political and social stability and low crime rates,[130] but also of innovation,[131] the rapid expansion of the Chinese middle class[132] and simultaneous contraction of that in the US did much to facilitate China's emergence as a more stable and innovative country. In 2020 China's middle class was 875 percent the size it had been just eighteen years prior in 2002, having grown from 80 million to 700 million people.[133] A 2010 working paper by the OECD projected that by 2030 China's middle class would grow to 73 percent of its population—up from 12 precent in 2009—with the addition of 850 million more middle-class Chinese. By contrast, North America's middle class was set to decline by 16 million people almost all from the US. Figures from 2020 indicated that both countries were on track to achieve the numbers predicted over the following decade.[134]

America's middle class had been fast shrinking since the late 1980s,[135] with 2015 having been a landmark where the number of low income households overtook it in size.[136] This trend accelerated sharply from 2020 with the COVID-19 crisis driving millions into poverty.[137] Other studies found that a sharp decline could be seen from multiple indicators including data from the Consumer Expenditure Survey and the definitions provided by the White House Middle Class Task Force.[138] Beyond a contraction in the size of the middle class, what it meant to be middle class in the US had itself changed, with many of those who remained technically within this shrinking demographic not having the ability to save money or enjoy financial stability as had been the case in the Cold War era.[139] The average incomes of middle class families shrank considerably after the turn of the century while they faced fast rising levels of debt.[140] A number of studies including a prominent one by the Brookings Institute, which established the Future of the Middle Class Initiative precisely in response to such trends, repeatedly reached similar conclusions.[141]

In parallel to the growth of the middle class, a fast increase in both the quality and quantity of education in China played an important role in cultivating a more innovative population. Where the unaffordability of higher education in the US[142] meant that fewer Americans were going to university,[143] in China the numbers receiving higher education were fast on the rise[144]—a contrast exacerbated further by the COVID-19 pandemic. In 2020 8 million students were graduating from China's higher education institutions annually, and this number was expected to grow threefold by the start of the next decade.[145] With the average yearly tuition at Chinese universities remaining under $1,600,[146] in contrast to the US where out-of-state tuition and fees cost an average of $26,820,[147] it was clear that even when considering the discrepancy in purchasing power between Chinese and American households higher education was almost ten times as expensive for Americans.

With China spending over $650 billion a year on education, the number of its universities ranked in the world's top 100 grew from just two in 2010 to twelve in 2020. Penetration of global rankings was an important indicator that alongside an increase in the number of institutions, quality was also being regulated and increased.[148] The BBC in 2016 referred to the rapid rate at which China was opening new universities as "part of a silent revolution that is causing a huge shift in the composition of the world's population of graduates." It stressed that the gap in the number of graduates between China and the West was set to widen considerably, and that "even modest predictions see the number of twenty-five to thirty-four-year-old graduates in China rising by a further 300 percent by 2030." While the United States had for decades accounted for the highest proportion the world's university graduates, which was reflected by the fact that among fifty-five to sixty-four-year-olds almost a third of all graduates in the world's major economies were US citizens, this was rapidly changing with China taking over the dominant position. The BBC report stressed that alongside a larger number of students, Chinese students were also "much more likely to study mathematics, sciences, computing and engineering—the subjects most relevant to innovation and technological advance." In 2013, 40 percent of Chinese graduates completed their studies in STEM subjects, where in the US this was under 20 percent.[149] The aforementioned significant discrepancies in the general quality of education only furthered this trend.

A better educated population with a larger, healthier and more affluent middle class were two of the major factors which facilitated high levels of innovation among the Chinese population, which increasingly surpassed those of the West. As noted by the *Harvard Business Review* in the spring of 2021, in an article titled 'China's New Innovation Advantage,' the East Asian country was "achieving a new level of global competitiveness, thanks to its hyper-adaptive population." Observing that the majority of the world's fastest startups to reach $1 billion valuation in the world were in China, the review highlighted: "China today has a resource that no other country has: hundreds of millions of people who have lived through unprecedented amounts of change—and who, consequently, can adopt and adapt to innovations at a speed and scale unmatched anywhere else on earth. Those hyper-adaptive and hyper-adoptive consumers are what make China so globally competitive today." "Certain developmental ecosystems create naturally different attitudes toward change, adoption, and newness," with China having a very clear global advantage in this respect.[150]

The rapid adoption of mobile payments systems—which Chinese users in 2020 spent $150 on for every dollar spent by Americans[151]—was cited in the article as a sign that China's consumers could adapt much more quickly to technological change. It stressed: "In the end, innovations must be judged

by people's willingness to use them. And on that front China has no peer . . . what happens when rapid adoption and adaptation become normal for more than 900 million internet users in every social stratum? You get an economic force that can change the terms of global competition." It further highlighted that the regulatory environment in China facilitated new innovations in a way that in the US did not, with this having played a key role in China's mobile payments boom. China was so far ahead that it was said to provide "an excellent way of peering in to the future," with the article citing the science-fiction writer William Gibson's statement "the future is already here—it's just not evenly distributed" to underline the discrepancy between China and its economic competitors as a result of the Chinese innovation advantage. "Some of the smartest non-Chinese companies already understand this and are looking to Chinese rivals for ideas," it concluded, citing multiple examples where American firms modelled new features on those which had been integrated several years prior in "futuristic" China. "Send your best and brightest to China. Expose them to new ideas there," was its advice.[152]

Government policies played an important role not only in terms of how they impacted the size and health of the middle class, but also in whether innovation was encouraged, whether the infrastructure and facilities to support it were in place, and whether its relations with the private sector would fuel or stifle progress. The contrast between Chinese and US policies toward fifth generation internet technologies (5G) were a case in point, and was a major factor in the discrepancy in 5G coverage in the two countries. Chinese consumers not only got 5G first, but the country closed in on 70 percent of all the world's 5G subscribers by mid-2020, and by the end of November reached 80 percent leaving the US very far behind.[153] This in turn provided China's tech sector with crucial first mover advantages which placed it in a much stronger position to launch the kinds of applications and features that would shape the 5G revolution.[154]

The discrepancy in trends in government support for research and development was another major factor in the Chinese innovation advantage. Stressing the importance of government spending on R&D in fostering innovation, which had been key to providing the US with a technological advantage in many key fields since the Second World War, *Time* warned in the title of a prominent 2019 article that "America risks losing its innovation edge." It cited diametrically opposing trends as China generously funded new research much as America had during the Cold War, while the US itself reduced funding, stating regarding the result of this America suffered:

> a reduction in basic scientific research that is aimed at creating the fundamental theoretical knowledge that can produce the seed corn that will eventually lead to great innovations . . . For almost twenty-five years, federal funding for

> university research and state funding for higher education has been in decline. Between 2011 and 2015, during the Obama administration, federal investment in university research declined by 13 percent. But it's now getting even worse. In the latest proposed budgets from House Republicans and the Trump administration, science and technology research federal funding would be cut by an additional 15 percent.

It stressed that China had taken precisely the "opposite approach," with Chinese leadership in AI being one of many results that had considerable, economic and security ramifications.[155]

Around the turn of the century and up to the mid-2010s the West's confidence in its continued primacy despite rapid Chinese growth rested heavily on the assertion that China's population, due to a combination of its culture and government system, would never be able to innovate as Western populations could. As a partner in a leading American management consulting firm told the writer in 2013, China "aren't considered a major economic challenge because they can't innovate, they aren't creative," indicating that this was seen as an issue across East Asia. In March 2014 the *Harvard Business Review* published the prominent article 'Why China Can't Innovate,' which was seen to capture conventional wisdom of the West at the time. It claimed that Chinese government policies were preventing the country from becoming a peer level innovator to compete with the US, with China seen as "a place where R&D is diligently pursued but breakthroughs are rare."[156] Two months later, then-US Vice President Joe Biden stressed in a speech at the US Air Force Academy in Colorado Springs that in contrast to America, China had not developed "one innovative project, one innovative change, one innovative product." He claimed that an inability to innovate would not only stifle China, but had stifled Japan before it, indicating that the argument was premised on cultural or even racial factors rather than on the system of government. "I want Japan to succeed, as I do China. But give me a break," he concluded.[157] This was hardly Biden's only statement to this effect, nor was it his first, with *Bloomberg* noting in its headline that he "makes a habit of dissing Chinese innovation."[158]

Western complacency regarding China's rise, on the basis of its presumed inability to innovate and therefore to compete at a peer level technologically, had significant historical parallels in previous very different kinds of conflicts. In the leadup to the Pacific War, US and British confidence in a swift victory over Imperial Japan rested on the assertion that Asiatics could neither fight nor develop first class weaponry.[159] Japan nevertheless successfully evicted the US, Britain and the Netherlands from their well-entrenched colonies across East Asia in a matter of weeks—often despite vast numerical disadvantages.[160] Similarly, at the outbreak of the Korean War, the presumed

racial qualities of the East Asian adversaries heavily influenced Western predictions of their battlefield performance leading many to expect North Korea's almost instant defeat in 72 hours or less.[161] As it was the North Koreans forced the US and its allies into a three-month retreat despite vast disadvantages in firepower and often in numbers, with the Chinese achieving a similar routing of US-led forces after entering the war four months later.[162] Much as the supreme commander of US and allied forces in Korea, Douglas MacArthur, had claimed that 'Chinamen can't fight,' shortly before facing overwhelming defeat and extreme casualties at their hands,[163] so too did the assertion that Chinese, or East Asians in general, couldn't innovate, foster complacency and leave the West open to stunning losses in the tech war. While the tech war was a very different kind of conflict to the West's military campaigns in East Asia, Western complacency on the basis of belief in their own superiority, due to a combination of cultural and racial factors, was largely consistent.

Increasingly from the late 2010s the idea in the West that China's lack of innovation would hinder it was seriously undermined by growing signs of prevailing technological trends, and such claims quickly faded from discourse on the issue. Longstanding assertions[164] that Western individualism would necessarily triumph over East Asian collectivism, and American laissez faire capitalism over Chinese socialism, were seriously challenged. A notable example was that by 2016 eight of the ten companies that had reached a $1 billion valuation in the shortest time ever were Chinese—with six of these having been founded in 2014.[165] By 2021, in the wake of an unprecedented spotlight being shone on Chinese technological developments due to the Trump administration's tech war and the surrounding rhetoric, it was widely being noted in publications such as *Foreign Affairs* that American and Western leadership in innovation was far from guaranteed.[166]

Chinese state policies consistently placed a strong emphasis on fostering innovation and securing supply chains, with these efforts often being complementary as the need to develop substitutes to foreign technologies domestically provided strong incentives to invent new solutions. At the Central Economic Work Conference in December 2020, China's ruling party expressly called for faster technological development and greater control over industrial supply chains with electric cars, telecoms and biotech highlighted as development priorities.[167] Statements and policies continued to signal the same priorities, with President Xi Jinping in May 2021 emphasizing the importance of breakthroughs in areas such as artificial intelligence, quantum computing and semiconductors and pledging to boost state investment and free scientists from bureaucracy. Addressing the country's top scientists, engineers and researchers, he stressed that scientific and technological competition had intensified to "unprecedented" levels, and had become "the

main battleground" of great power rivalry. He called for closer cooperation between the private sector and academic institutes, and for institutes to move away from the 'paper only' mindset and focus more on their research's innovative value and its contribution to society.[168]

Chinese government efforts to move industry up major value chains were based around both the aforementioned Five-Year Plan as well as multiple longer term national strategic plans. One of the most prominent was the 'Made in China 2025' strategic plan publicized in May 2015, which focused on moving the Chinese economy to concentrate more on "innovation-driven development." The plan played a central role in efforts to be a leading competitor at the top of value chains in strategic fields such as semiconductors,[169] robotics and aviation.[170] Such efforts were perceived in the West as an imminent threat, with the stakes for Western economies being tremendously high. With broader industry in the US and the wider Western world having deteriorated sharply (see chapter eight), primacy in innovation and creating and dominating technologies at the top of important value chains had become even more vital to sustain Western affluence and geopolitical power. If this dominance was lost, it risked largely blurring the distinction between the West and the middle-income third world. The highly influential Council on Foreign Relations think tank stressed that "In the saga of the US-China economic rivalry, Made in China 2025 is shaping up to be the central villain, the real existential threat to US technological leadership." It claimed in a prominent report that in the West, "everyone hate[s] made in China 2025."[171] The European Union's European Commission published a more benign assessment which concluded the Chinese plan was similar to "German and Japanese approaches to innovation and economic development." It was hardly an unprecedented or malign plan despite what discourse in the US consistently indicated, but was still potentially transformative for the balance of economic power globally.[172]

The rationale and sentiment behind Western opposition to Made in China 2025 was perhaps best summarized by US Senator Marco Rubio, who in February 2019 led the US Small Business Committee to propose an explicit American industrial policy response to the initiative centered around taxes and restrictions on Chinese investments in America.[173] Rubio's official website published regarding the reason for this: "in theory, the production of cheap and mass-market consumer goods in China would produce an increase in the standard of living for American consumers and allow the US to increase high-value exports to China. But what happens if China makes these high-value products instead? This is the future envisioned by the 'Made in China 2025' plan first promoted by the Chinese government in 2015."[174] Essentially while the lower end of value chains was seen in the West as a

proper place for China and its industries, Beijing's efforts to move up key value chains as its economy developed were viewed highly negatively.

At the Nineteenth National Congress of the Communist Party of China in 2017, the goal was set to build a "moderately prosperous society" to allow the population to live comfortably, albeit ordinarily, with higher consumption rates, a cleaner environment and a larger middle class. While not directly related to high tech or innovation, this medium-term goal effectively complemented plans to move industry up value chains and increase economic self-reliance by creating a workforce that was both more innovative and more affluent and thereby providing a greater base for domestic consumption.[175]

Following two years of planning the 'China Standards 2035' strategic plan was unveiled in 2020 and represented a fifteen-year blueprint for Chinese firms to take the lead in international standard setting in key next-generation technologies. Huawei's success in doing so in 5G as the undisputed leader in the field (see chapter four) was seen by some analysts to herald a broader trend toward Chinese firms dominating much of the next generation of technologies which the new state plan would effectively support. With the plan widely seen as a follow-on to 'Made in China 2025,' Elsa Kania from the Centre for a New American Security was one of many experts to observe: "Technical standards is not a topic that is simply abstruse but a concrete way to shape the playing field and landscape for the future of these technologies. The decision made on standards can have commercial consequences while also shaping the architecture to the advantage or disadvantage of companies."[176]

Chinese firms had already moved secure major roles in standard setting for key emerging technologies such as blockchain[177] and nascent space.[178] As co-founder of the Horizon Advisory consultancy, Emily de La Bruyere, observed: "The diagnosis is, we are entering an era that will be defined by new technological systems and networks and technologies and the leaders in those are yet to be determined and this gives China the opportunity to determine that. That means power in the world is up for grabs."[179] She described the ability to set tech standards as providing the ability to: "set the rules for the future world, especially the technological rules as we enter into a new technological era" and gain an "inherent industrial competitive advantage."[180]

China Standards 2035 was expected to be closely linked to the Belt and Road Initiative, a far-reaching global infrastructure development plan initiated in 2013 to enhance Eurasian and African connectivity through a network of roads, rails and ports which was expanded in 2019 to include technology.[181] This would potentially facilitate the easier proliferation of Chinese technological standards alongside its investments in over 60 countries involved in the initiative. Director of the Council on Foreign Relations digital and cyberspace policy program Adam Segal was one of many to predict that developing

countries such as Vietnam and Indonesia would be much more inclined to adopt Chinese standards than Western ones. With developing countries making up the large majority of the world, this placed the West at a potentially decisive disadvantage. In contrast to China, relatively little attention was paid in Washington to the importance of determining which parties set international standards for key emerging technologies.[182]

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Chapter 2

Artificial Intelligence

The Most Critical Technological Race?

ARTIFICIAL INTELLIGENCE IN CHINA AND THE US

Artificial Intelligence (AI) has been widely seen as the most strategically and economically critical new technology in the Fourth Industrial Revolution, and is expected to bring about unprecedented technological change driven by an explosion of computing power and growth of connectivity. Notoriously difficult to define, AI refers to artificial systems able to perform different kinds of machine learning—essentially to 'think' for themselves with minimal human intervention, learn from data and make accurate assessments and predictions. This could range from basic functions, for example a computer able to play chess or poker, to something more sophisticated such as a computer connected to sensors to process complex data inputs. At a more advanced level, AI could be capable of Deep Learning—adapting itself to new data and training itself to learn and recognize patterns. Across the economy, from manufacturing and R&D to finance and defense, the implications of advances in AI are considerable. As advances in AI accelerated in the 2000s, and moreso after 2010, the significance of its implications for all major areas of advanced economies from manufacturing and R&D to finance and defense have been increasingly apparent. Growth in the field from 1998 to 2018, during which time the number of published peer review data AI papers grew more than fourfold, was described by experts in January 2020 as representing "just the leading edge of this massive wave" as the rate of growth would increase rapidly over the following decade. China led growth in research and in publishing, surpassing the United States in journal publications on AI as early as 2006.[1]

From the late 2010s China appeared increasingly well placed to lead the new industrial revolution, which was strongly emphasized in its Fourteenth

Five-Year Plan issued in 2020 under which development of key "frontier technologies" was made the top policy priority. These included artificial intelligence, quantum computing, semiconductors, neuroscience, genomics and biotechnology, clinical medicine and health, as well as deep space, deep earth, deep sea and polar research. Chief economist at Pinpoint Asset Management, Zhang Zhiwei, was one of many to observe that China and the US "both recognise that these technological breakthroughs can lead to a change in the landscape of the global economy."[2] Regarding the potential implications of the race for dominance in new technologies, former Google Ideas director and state department advisor Jared Cohen and Chief Executive Officer of the Centre for a New American Security Richard Fontaine, together observed: "whoever shapes the use of emerging technologies such as AI, quantum computing, biotechnology, and next-generation telecommunication will have an economic, military, and political advantage for decades to come."[3] A more dramatic and more widely publicized statement to this effect came from Russian President Vladimir Putin, who stated three years prior in 2017: "Artificial intelligence is the future, not only for Russia, but for all humankind . . . Whoever becomes the leader in this sphere will become the ruler of the world."[4] A prominent paper on the subject from Taiwan's CTBC Business School published four years later was one of many to note to similar effect:

> it has become an article of faith amongst those in the commanding heights that whoever unties the 'AI Gordian Knot' would dominate the 21st century. China's palpable ambition to dominate this AI future, backed by overwhelming financial might, makes it the leading contender in this race and seemingly inevitable victor.[5]

Superior industrial policies and incentives, coupled with the world's largest industrial base and a central place in most tech supply chains, allowed China to capitalize on the Fourth Industrial Revolution and its transformation of the global economy to make a move for the top of global value chains. These positions had been dominated exclusively by the Western world, Japan and South Korea since the Cold War's end. The 2021 white paper 'Reimagining Operations for Growth,' published by the World Economic Forum in collaboration with consultancy firm McKinsey, reported that of the sixty-nine factories around the world viewed as leaders using Fourth Industrial Revolution technologies twenty were located in China followed by nineteen in the European Union, seven in the US and five in Japan.[6] As artificial intelligence matured further, it was set to play an increasingly central role in determining which countries led in multiple fields. With the rate of advances continuing to

accelerate particularly from the mid-2010s, those countries and firms which sought to be major players could not afford to delay investing.

Highlighting the sheer speed of development, former US deputy secretary of defense and former CEO at the Centre for a New American Security Robert O. Work stated in January 2020:

> Post 2012, which is where AI and machine learning has really started to grow, computer power has been doubling every 3.4 months, and as a result in just the last year-and-a-half the time required to train a large image classification system on cloud infrastructure has fallen from three hours in October 2017 to 88 seconds in July 2019. So you train your image classifier in 88 seconds. During the same period the cost to train such a system has fallen similarly, and the same thing is happening in natural language processing which is going to allow humans to interact with AI empowered systems in a much more convenient and personal way.[7]

A major event which attracted world attention to the rapid advances in AI and the magnitude of its implications occurred from March 9 to March 15, 2016, when Google's AlphaGo machine-learning system beat the Go world champion Lee Sedol. The boardgame Go had long been considered the most complex two player game in the world, and for years was the only one in which artificial intelligence failed to best human players after having decisively done so years before in all other games including in chess in 1997. The number of potential legal board positions was a fifty-nine-figure number—more than the number of atoms in the known universe. It was widely believed that an AI able to beat a professional Go player was a decade or more away, but AlphaGo's use of algorithms and reinforcement learning to train on massive datasets and predict outcomes allowed it to form sophisticated strategies beyond the limits of the human mind. Such an achievement represented a major landmark in the development of AI to gain superiority over humans.

If artificial intelligence could beat humans at Go, it meant it could learn to do so at anything simpler than Go and in the coming decade expand the scope of tasks in which humans became effectively obsolete with further revolutionary advances. This has significant implications not only for the workforces across the developed world, particularly as AI technologies continued to become cheaper and more readily available, but also for great power competition. Go's complex strategic nature drew attention to the possibility that AI could have significant military applications, as well as broader strategic ones which had the potential to prove decisive in war as well as in colder forms of inter-state conflict.

The AlphaGo-Lee Sedol match took place in Seoul, South Korea, and was watched live by 60 million people in China, 100,000 people on Youtube and

hundreds of members of the press and aired on most major South Korean television networks due to its tremendous implications. Most had expected Lee to win—as Go champions had consistently done against AI before. What was particularly notable about AlphaGo, however, was its ability to improve and 'learn' very quickly, with a very noticeable improvement compared to its performance just five months before its match against Lee. As the *Atlantic* observed:

> it is always improving, playing itself millions of times, incrementally revising its algorithms based on which sequences of play result in a higher win percentage. As you are reading this, AlphaGo is improving. It does not take breaks. It does not have days when it just doesn't feel like practicing, days when it can't kick its electronic brain into focus. Day in and day out, AlphaGo has been rocketing towards superiority, and the results are staggering. . . . If AlphaGo had lost to Lee in March, it would only have been a matter of time before it improved enough to surpass him . . . Humans have been honing our collective knowledge of the game for more than 2,500 years—the difference is that AlphaGo can do the same thing much, much faster.[8]

Lee Sedol's defeat significantly increased world attention on AI and placed the magnitude of advances in the technology in a context which could be more widely understood. Two days after his final match, the South Korean government announced that in response to the game's outcome it would invest 1 trillion won ($863 million) in a fund for AI development over the next five years.[9] Citing experts who consulted with the US government, the *New York Times* noted that Lee's defeat "had a profound impact on politicians in China" and served "as a sort of Sputnik moment for China" which "paved the way for a new flow of funds into the discipline."[10]

Five months after Lee's defeat, President Obama made a veiled reference to the game to highlight its potential implications for the future of AI, stating:

> If you've got a computer that can play Go, a pretty complicated game with a lot of variations, then developing an algorithm that lets you maximize profits on the New York Stock Exchange is probably within sight. And if one person or organization got there first, they could bring down the stock market pretty quickly, or at least they could raise questions about the integrity of the financial markets.[11] Then there could be an algorithm that said, 'Go penetrate the nuclear codes and figure out how to launch some missiles.' If that's its only job, if it's self-teaching and it's just a really effective algorithm, then you've got problems.[12]

Seven months later on the October 12 and 13, although not formally linked to the game, the Executive Office of the President of the United States released two papers for the purposes of 'Preparing For The Future of Artificial

Intelligence'[13] and laying out a 'National Artificial Intelligence Research and Development Strategy Plan.'[14] The speed at which they were prepared relative to other national plans was seen by analysts as an indicator that "the Obama administration clearly sees AI as an urgent priority." Expanding the AI R&D workforce was a key theme across both reports, although it was noted by analysts that there was otherwise no clear vision regarding where to focus research funding. Despite a long list of research topics being provided, it was not delineated which were commercial and which would require government support.[15] A further paper released on December 20 focused on the broader impacts AI would have on the US economy.[16] The reports notably received more attention in China than they did in America itself.[17]

Near the end of his term President Obama joined many other voices in comparing the race for AI to the space race of the Cold War era, and gave an indication of the size of the investments that could be needed to compete. He stated:

> The analogy that we still use when it comes to a great technology achievement, even fifty years later, is a moonshot. And somebody reminded me that the space program was half a percent of GDP. That doesn't sound like a lot, but in today's dollars that would be $80 billion that we would be spending annually . . . on AI.[18]

On July 20, 2017, China's State Council released 'A New Generation Artificial Intelligence Development Plan,' which was described as "a forward-looking plan related to the overall and long-term" for AI development. The plan stressed that "the rapid development of artificial intelligence will profoundly change human society and life and change the world," and that it had been formulated "to seize the major strategic opportunity for the development of AI, to build China's first-mover advantage in the development of AI." Regarding funding for AI, it indicated plans to: "Make full use of existing funds, bases and other stock resources, coordinate the allocation of international and domestic innovation resources, give full play to the guiding role of financial investment, policy incentives, and the leading role of market allocation resources, and spur enterprises and society to increase investment to form financial funds and financial resources." Also highlighted were the importance of "building an artificial intelligence innovation base," "coordinating international and domestic innovation resources," "formulating laws, regulations and ethical norms that promote the development of artificial intelligence" as well as setting standards for ethics, intelligence technology and intellectual property. Popularisation of AI and strengthening the AI labor force also featured prominently in the plan, which was considered to be at the core of China's AI strategy.[19]

Referring to AI as "a new engine of economic development," the goal of China's new plan, which was laid out in a three-step roadmap, was to make AI an industry worth 1 trillion yuan ($147.7 billion) by 2030. AI related fields would be worth 10 trillion Yuan ($1.477 trillion), and these technologies should be expanded and their use deepened in multiple domains including social governance and national defense. After gaining the ability to keep pace with leading AI technology by 2020, a goal which was comfortably achieved**,** the plan's second stage from 2020–2025 would see China achieve "major breakthroughs" in AI technology and its applications to facilitate "industrial upgrading and economic transformation." This would be followed by the country emerging decisively as the world's the "premier global AI innovation centre" from 2025–2030 to "occupy the commanding heights of AI technology."[20] The *New York Times* noted that the new AI development plan would "work as a signal to local governments across the country" and led "a large number of local governments" to create "special plans and build out research centres to focus on AI," with some spending billions at the local level for research and development. It notably contrasted this approach with the US government's cuts to science funding, highlighting that China's "multiple-decade industrial policy" had yielded promising results with the country "making quick progress" in AI.[21] Closely coinciding with the plan's release, China's ruling party issued the following cabinet statement: "By 2030, our country will reach a world-leading level in artificial intelligence theory, technology and application and become a principal world centre for artificial intelligence innovation."[22]

The year 2017 also saw a very sharp rise in funding for AI, and while China had been responsible for just 11.3 percent of global equity funding for AI startups in 2016 this rose to 48 percent the following year compared to 38 percent funded by the US and 13 percent by the rest of the world. The Chinese AI industry grew by 67 percent that year.[23] By 2017 Chinese AI startups were already raising $4.9 billion annually in venture capital funding, with startups in the US raising $4.4 billion. The difference in funds available to startups was considerably greater when considering the dollar's far higher purchasing power in China meaning each dollar could purchase much more. The figures, released by New York-based global tech market advisory firm ABI Research, reflected the extent to which China and the US were leading the world in AI, with the two between them responsible for 87 precent of the world's AI venture capital investments. Principal analyst at ABI, Lian Jye Su, stated regarding the findings: "The bullish sentiment shared among Chinese investors is a clear sign that China is going all-in in artificial intelligence . . . The government of China is setting clear policy guidelines for the future development of AI, and startups are responding with cutting edge AI technologies across many industries."[24] These trends would prevail in subsequent years.

In July 2018 the China Institute for Science and Technology Policy at Tsinghua University published an AI Development Report highlighted that China had already "secured a leading position in the top [AI] echelon in both technology development and market applications and is in a race of 'two giants' with the US." In terms of global rankings, it showed that China already held first place in total AI research papers, highly cited AI papers, AI patents and AI venture capital investment. The US still maintained a lead in the number of AI companies and in the size of its AI talent pool, but prevailing trends indicated that this was likely to soon change.[25]

The sustained attention China's ruling party gave AI only increased with time, and available data indicated that total government spending in the field was in the tens of billions of dollars even before 2020. President Xi Jinping and others in the party leadership expressed the belief that leading in AI was critical to China's ability to compete both economically and militarily in future. A sign of this focus came in October 2018 when President Xi led a Politburo study session on AI. Such sessions were reserved only for very high priority policy issues to provide the party leadership with outside expertise. At the session Xi said that China must "ensure that our country marches in the front ranks where it comes to theoretical research in this important area of AI, and occupies the high ground in critical and AI core technologies." He further stressed the need to "ensure that critical and core AI technologies are firmly grasped in our own hands."[26]

In February 2019 the Donald Trump administration made its first major move in the AI field with the implementation of the much-anticipated American AI Initiative, also known as the Trump AI Initiative, by executive order. This represented an escalation of government efforts to accelerate AI development, and while the Obama administration had laid out AI roadmap, its successor went considerably further by implementing actual policies.[27] The Executive Order on Maintaining American Leadership in Artificial Intelligence called explicitly for American primacy in AI. It provided researchers with access to federal government data and required federal funding agencies to prioritize AI investments in their allocations and to train people for changes resulting from AI through apprenticeships, fellowships and training programs.[28]

The initiative was seen by experts as a step in the right direction, albeit a somewhat underwhelming one compared to the Chinese government's own AI initiatives. Issuing an executive order on AI nevertheless represented part of an escalation in government intervention to ensure the US could remain competitive in the field in the face of rapid Chinese progress. President Trump stated at the time that American leadership in AI was "of paramount importance to maintaining the economic and national security of the United States."[29] Considering that the Trump administration had consistently

proposed deep cuts to research and development funding, and in 2020 cut 6.5 percent of the National Science Foundation's overall budget, the fact that it at the same time doubled the foundation's AI research budget was a sign of its perceived importance.[30]

Concerns in the US and the wider Western world that Chinese leadership in AI could seriously challenge the existing Western-dominated global order were widely expressed by prominent figures and far from restricted to those in government. A report from the *MIT Technology Review* in December 2019 referred to a "deep-seated fear within the policy community that the US is sorely losing in the so-called AI arms race," noting that China was outspending the US on research even in real terms and without considering the discrepancy in purchasing power. It further warned that the US risked "focusing too much on military AI and too little on more fundamental research," with spending disproportionately focused on developing applications of the technology for the Pentagon.[31] Chief technology officer at the White House Office of Science and Technology Policy Michael Kratsios highlighted in September 2019 that primacy in AI was vital to "stay true to our values and preserve our dominance." He emphasized: "So today our goal is very clear. This uniquely American ecosystem must do everything in its collective power to keep America's lead in the AI race and build on our success. Our future rests on getting AI right."[32]

Director of the Technology and National Security Program at the Center for a New American Security think tank, Paul Scharre, stated to similar effect in January 2020:

> it wasn't that long ago where if you were running around Washington talking about artificial intelligence, people would think you'd been watching too many science fiction films. That changed a lot in just the past few years, and now we see a growing awareness across Washington, in the White House, Congress and different agencies about the importance of this technology, the revolution we've seen in the past two years in machine learning, and how this is changing different elements of society and national security as well. And that the US needs to find ways to respond and adapt. It's important that the US maintains a leadership position in this technology, not just so that we can stay ahead of potential competitors, but also to shape how this technology is used around the world. [33]

Former deputy secretary of defense Robert O. Work noted in January that at the Pentagon there was "certainly no technology that we could identify would have as broad of an impact on national security as artificial intelligence." Regarding investment in the field, he stated: "You have the White House which is really starting to lead the charge on how AI can be used throughout the United States to make us healthier, safer and more productive and more

economically viable . . . We believe it is fundamentally important to set the rules, the global norms and standards and rules" for the use of AI.[34]

Senior fellow for public policy at the Centre for a New American Security think tank, Martijn Rasser, stated that the US government needed to be spending $25 billion annually on AI by 2025. The White House pledged in February 2020 to increase spending on non-military AI research to $2 billion annually, although considering the state of the US economy by the end of the year its ability to consider more ambitious spending targets was highly questionable. While Rasser and others who had a greater understanding of AI's importance could advocate massive investments even at a time of unprecedented economic crisis, it would be far more difficult to persuade policymakers to divert funding to research in the field.[35]

Chair of the National Security Commission on Artificial Intelligence (NSCAI) and former Google CEO Eric Schmidt stressed on multiple occasions that ensuring Western dominance of AI was vital, and warned in August 2020 that China would lead the world in AI if Washington failed to increase funding for research. "If we don't act now, in ten or twenty years we'll say, 'How could we have missed this?,'" he stated at a Bipartisan Policy Centre think tank event. Schmidt stressed that government funding was vital because the amount of additional funds needed to compete with China were tremendous, and no private entity, including Google, would be able to meet the funding requirements.[36]

In a somewhat dehumanizing comment toward China, Schmidt stressed in October 2020 that it was essential for the West to be ahead of the East Asian state in setting AI standards to ensure that these standards reflected "human values." Regarding its implications for both economic development and security, Schmidt stated: "AI is the lynchpin of much of the next phase of interesting research and science [for] solving most of the problems in the future whether its biology and genetics or all sorts of other problems, they involve leadership in AI." He particularly stressed: "We want America to be inventing this stuff, or at least the West. Its just much much better . . . This is a critical fight."[37] "At least the West" was a particularly insightful comment which indicated that what was being fought for was not an alliance or a set of value systems, with America's most high-tech strategic partners Japan, South Korea and Taiwan seldom mentioned. Rather, "at least the West" indicated that the struggle was seen as one to maintain Western primacy—ensuring that centuries of Western-dominated world order could be perpetuated for which Western leadership in AI was vital.[38] This was hardly an isolated statement, another notable example being Schmit's lamenting in 2021 that the new generation of technology giants "are not going to be European or American but Chinese," again indicating that Western primacy was the goal.[39] Schmidt was far from alone in expressing such sentiments, with a perceived need to

maintain Western supremacy being a key driver of multiple initiatives to counter China many of which related to technological competition.

CAN AMERICA COMPETE WITH CHINA IN AI?

By the time the Trump AI Initiative had passed Chinese AI startups had been receiving more venture capital than their US counterparts for some years[40] and the country's leading AI firms such as SenseTime, Megvii and YITU Technology were raising billions in funds. China was publishing more AI research papers annually than any other country, with a strong lead in papers on deep learning which was a particularly complex subset of machine learning in artificial intelligence.[41] A study published in December by information analytics firm Elsevier found that between 1998 and 2017 106,600 AI research papers were published in the US while 134,990 were published in China. The two countries were in a league of their own, with the third place held by India which had under 40,000 publications.[42] Following a 35 percent rise from 2019, China also overtook the US for AI citations in 2020.[43] Prevailing trends strongly indicated that China's lead would grow considerably wider over the coming decade and up to 2030, with multiple experts warning that the American private sector wasn't moving fast enough to embrace the new technology.[44]

Research Associate for the Technology and National Security Program at the Center for a New American Security, Megan Lamberth, was one of several experts to highlight that a shortage of educated AI talent domestically was a major issue which undermined America's ability to complete internationally. She stated to this effect: "it's clear a shortage of AI talent exists. There simply are not enough STEM educated Americans to fill the ever growing number of AI-related jobs. And even if the US were to adopt a fully funded, long-term educational initiative to train US students in STEM, this kind of effort would take decades to realize." With this issue expected to only worsen in the long term, and with no educational initiatives even being proposed that could turn back the decades long trend toward decline and underperformance, this was a potentially decisive impediment to America's ability to compete with China in AI. Lamberth stressed that the solution would be to renew efforts to attract overseas talent and thereby compensate for domestic deficiencies. This assessment and strategy strongly reflected the aforementioned assessments by Professor Michio Kaku and other regarding the nature of American STEM education and the country's tech sector.[45] Indeed, with 69 percent of AI researchers at US institutions having received their undergraduate degrees from abroad, and two-thirds of graduate students in America's top AI-related PhD programs also being foreign, approximately 80 percent of whom stayed

on five years after graduation, AI was a perfect example of America's extreme reliance on foreign talent to be able to compete in high tech.[46]

Economic crisis in the US from 2020, and bipartisan support for a reduction in high skilled immigration which was reflected in legislation passed under both Trump and Biden, meant that rather than recruiting more foreign AI talent to compensate for its own serious deficiencies, America was increasingly turning it away. As observed in the title of a prominent July 2020 article by the *MIT Technology Review*, "The US is turning away the world's best minds—and this time, they may not come back: New restrictions will prompt would-be immigrants to look elsewhere. Many may find America is no longer their best option." It stressed that "a slew of new barriers to skilled immigrants" was "part of a trend that began long before the [COVID-19] pandemic but has sped up dramatically in the past few months," noting that attempts to rely more heavily on domestic talent simply "won't provide the talent the US needs in the short and medium term in fields like AI." It further emphasized that in fields such as AI, quantum computing and biotech, the attraction of working in the US had diminished considerably as flourishing tech hubs were established elsewhere. "Immigration initiatives may erode America's historic advantage in technology and other fields . . . America's historic near-monopoly on the global market for foreign talent is fading, and the stakes are getting higher," it concluded.[47]

Moves by Washington to suspend visas for skilled workers were roundly criticized by prominent figures in the American tech sector such as Google CEO Sundar Pichai,[48] SpaceX and Tesla founder Elon Musk[49] and AI pioneers Andrew Ng[50] and Yann LeCun.[51] All of them had notably themselves migrated to the US on temporary visas, and stressed that new restrictions would hinder the country's capacity for innovation. Apple's director of machine learning, Ian Goodfellow, similarly lamented regarding both the importance of recruiting foreign talent for AI, and the government's restrictions on firms' ability to do so: "My collaborators' visa restrictions have been one of the largest bottlenecks to our collective research productivity over the last few years."[52]

A separate 2020 article from the *MIT Technology Review* noted more specifically in its title that restricting visas for skilled migrants "could threaten US dominance in AI." It highlighted that even before the Trump administration, immigration policies were "creating a bottleneck for meeting domestic demand for tech talent," with new restrictions having "left many policy analysts worried about what it could mean for long-term US innovation." Citing research by the think tank MacroPolo, it stressed that AI talent from abroad absolutely could not be replaced by Americans.[53]

With China already fast increasing its lead, US policies not only failed to address but actually exacerbated the country's severe shortage of AI talent. China's education system ensured that it could rely on a vast and

fast-growing domestic talent base which, even if the US could continue to attract foreign-educated talent, it would seriously struggle to match. Founder of Chinese venture capital firm Sinovation Ventures and veteran tech investor Lee Kai-fu, a former senior executive for Google and Microsoft, was one of many who stressed that "the large number of science and engineering college students in China give the country a unique advantage in AI development."[54]

The discrepancy in general education was also important to determining how easily AI could be adopted, a notable example being the US military where, as the *National Interest* observed in the title of a major article on "data-illiterate culture": "illiteracy, not morality, is holding back military integration of artificial intelligence." According to the 2021 article, this issue:

> exists across the Department of Defense and among powerful constituencies within the military services. It starts with a paucity of understanding the value of data and the data science that drives the artificial intelligence and machine learning (ML) revolution. . . . the US military is failing to adapt to the automated battlefield in scope and speed. The Department struggles to apply AI/ML to military functions outside of the narrow tasks of reconnaissance, surveillance, target acquisition, and prosecution. The reason for this narrow scope and glacial pace of exploitation is data-illiteracy.[55]

This issue was widely alluded to, including by the Defense Secretary, and affected the civilian economy in much the same way as it did the military.[56]

Not only did China retain very significant advantages in its AI workforce, funding and the amount of support the government was willing to provide, but it also led the world by a considerable margin in research. As a prominent article in the *Harvard Business Review* highlighted in February 2021: "Twenty years ago, there was a huge gulf between China and the United States on AI research . . . But in the intervening years, China has surged to rapidly catch up. From a research perspective, China has become a world leader in AI publications and patents. This trend suggests that China is also poised to become a leader in AI-empowered businesses, such as speech and image recognition applications." It highlighted, however, that the fact that most AI patents[57] in China were field by universities and research institutes rather than by companies could limit its ability to make technological breakthroughs as the more private sector driven American research could. Some analysts postulated that this could help to partly compensate for the Chinese advantage in the sheer scale of research and sheer number of innovations as the private sector, which was responsible for a larger proportion of American AI research, would be more efficient and 'results driven.' The scale of growth of China's private sector research into AI, however, meant that it was well positioned to overtake that of the US. As observed in the *Harvard Business*

Review, China's market was "conductive to the adoption and improvement of AI," and government policies in the country "send a clear signal to different AI stakeholders, including entrepreneurs, investors, and even researchers, that AI is a field that is being backed by the government and is worth investing."[58]

While the Chinese and US AI sectors, like much in their economies, had been strongly intertwined, new American restrictions on tech exports imposed on January 6, 2020, banned the sale of several types of AI software. Like many of the Trump administration's trade policies, this was primarily targeted at China and served to partly bifurcate the two economies' tech sectors particularly in the field of AI with the effect of hampering the rate of progress in both.[59] As noted by adjunct fellow with the Centre for a New American Security's Technology and National Security Program, Elsa Kania, regarding the consequences of the series of measures taken by Washington to this end:

> My main concern about some of these policy measures and restrictions has been that they don't necessarily consider the second-order effects, including the collateral damage to American companies, as well as the ways in which this may lessen US leverage or create much more separate or fragmented ecosystems. Imposing pain on Chinese companies can be disruptive, but in ways that can in the long term perhaps accelerate these investments and developments within China.[60]

By 2020 it was increasingly evident that China was set to gain a considerable lead in AI.[61] On March 1, 2021, the US National Security Commission on Artificial Intelligence published a thorough 756-page report detailing how China was expected to establish itself as the undisputed leader in the field and why America was in a poor position to compete. Its goal was to present "a strategy to defend against AI threats, responsibly employ AI for national security, and win the broader technology competition." The commission, chaired by Eric Schmidt, had been established by in 2018 to consider the means to advance AI development to address America's national security and defense needs. In the opening letter to the report, Schmidt and Vice Chair Robert Work warned that the US suffered from a lack of preparedness or expertise to compete in AI. "America is not prepared to defend or compete in the AI era," they concluded. They strongly advocated cooperation between the US government and "committed partners in industry, academia, and civil society" as well as overseas partners and allies to ensure America could compete in and go on to dominate AI.[62]

The report followed the prevailing trend in the US of portraying the competition for primacy in AI as a Cold War-type clash of ideologies and value systems. "The AI competition is also a values competition," it stated, warning

that "China's plans, resources, and progress should concern all Americans." It called for the government to aim for $32 billion a year in AI R&D spending by 2026, as well as a major boost in funding for the Defense Advanced Research Projects Agency (DARPA) to sponsor research projects relating to AI. Its primary conclusion was that the Defense Department and the US intelligence community had to be "AI-ready" by 2025 at the latest, and that a significant talent deficit in both organizations was seriously undermining preparedness for the AI-driven battlefields of the future. AI-readiness referred to widespread integration of AI tools and a focus on training and recruiting the best talent from related industries.[63]

China continued to surprise analysts in the speed at which its AI sector was advancing, a notable example being the funding of its first factory for 7nm General-Purpose Graphics Processing Unit AI computing chips in April 2021. These chips, which could perform non-specialized computations and combined CPU and GPU processing power, featured parallel processing capabilities and had high memory bandwidth. These chip technologies had been considered one of the few AI-related fields where the US had retained a significant lead over China, and the factory's opening signified that remaining US areas of advantage were fast diminishing.[64] The importance of this development was particularly critical, since reports from think tanks such as the RAND Corporation had repeatedly stressed that the US depended heavily on a lead in AI semiconductors to maintain any kind of edge in AI over China as it fell increasingly behind in other areas.[65]

As noted as early as 2017 by director of research at analyst firm Gartner, Anthony Mullen, "right now, AI is a two-horse race between China and the US." The former, he noted, was well positioned to prevail with its government funding and support, lively research community, large consumer base, and society primed for technological change. He further noted China's political culture was potentially highly advantageous, with the nature of Western political culture meaning America could face "existential crisis about the development of AI."[66] As noted by Matt Scott, CTO of the Shenzhen AI startup Malong Technologies, the greater willingness in China to take risks with technologies was an important advantage. "For AI you have to be at the cutting edge. If you're using technology that's one year old, you're outdated. And I definitely find that in China—at least, my community in China—is very adept at taking on these risks," he stated. Scott further highlighted that China had a particularly open AI community with "more emphasis on [personal] relationships" and with chat groups centred around universities and companies sharing and discussing new research, which was highly advantageous.[67]

The contrast between the successes of Microsoft chatbots in China and the US was widely highlighted by Western analysts as a good indicator of some of the distinct advantages Chinese society had in smoothly adopting

AI.[68] Chatbots were AIs designed to simulate human conversation, which when advanced enough could 'learn' from their conversation partners and evolve over time. In China the Xiaoice bot, which was downloadable as an app, had over 40 million users with regulars talking to it every night, and even published a book of poetry under a pseudonym which sparked debate in the country about artificial creativity.[69] The American version named Tay, by contrast, was shut down in just a few days after users taught it to be bigoted and abusive.[70]

Greater political stability and continuity in Beijing, in contrast to Washington where policies including the approach to AI could change suddenly and significantly with a new administration every four or eight years, was cited as another important factor which advantaged China. As observed by widely by prominent US experts, government support for technological development was irreplicable and key to long term development of strategically vital fields, where the private sector focused much more on the kinds of innovations that would yield faster profits but not necessarily strengthen the country's position in the long term.[71] Strong private and public sectors were needed for an optimal ability to compete in AI, which was something the US notably lacked due to the underwhelming role the government played in the sector. Closer collaboration between firms, universities and the government, and much bigger partnerships such as the "national laboratory for deep learning" run by Baidu and the Chinese government's National Development and Reform Agency, were seen to give China an advantage.[72] The only distinct and widely cited advantage the US had, which China was not expected to quickly close the gap with, was its greater ability to attract foreign talent and expertise, which was facilitated by decades of worldwide investments in cultivating soft power[73] and by low language barriers.[74] America's ability to continue to attract AI talent in the numbers required, however, will for aforementioned reasons likely be significantly diminished although still remaining superior to that of China.

ARTIFICIAL INTELLIGENCE AND COVID-19: WHEN CHINA DEMONSTRATED ITS AI ADVANTAGE

The COVID-19 crisis saw China extensively leverage its advances in artificial intelligence to respond and mitigate the extent of the damage, with applications ranging from drones to enforce social distancing to diagnostic tools and contact tracing. The emergency situation in early 2020 provided a unique insight not only into how advanced Chinese AI was, but also the degree to which it was practically applicable and could be applied in new ways on short notice. As a prominent paper on the subject from Taiwan's

CTBC Business School written in 2020 noted: "The onset of the COVID-19 pandemic has revealed to the world the remarkable progress China has made in AI and its accompanying ecosystem. More importantly, this outlier event demonstrates the surgical, hybridised manner in which China has utilised these emerging technologies in containing its spread and set itself on the path to unleashing their full potential." It highlighted "technological brilliance of China's high-tech campaign to eradicate COVID-19," which had been a game changer and underlined its leadership in developing and applying AI. It further noted that the pandemic provided a valuable case study to measure the country's progress in AI, and that "without outlier events such as COVID-19, the world may not have realised the significant strides China has made in AI."[75]

China's tech sector had been particularly well prepared to apply AI in the medical field. A notable example was Tencent Holdings' moves to lead the development of computer vision for medical diagnosis after it was tasked with doing so in 2017. Tencent shortly afterwards unveiled an AI medical imaging platform that could diagnose a broad range of illnesses, as well as a cloud-based ecosystem for sharing and collaboration between domestic healthcare AI firms. Another notable example from 2017 was the development of a robot by iFlyTek that could pass China's written national qualification exam for doctors, which was seen as a potential game changer for the country's healthcare system.[76]

As noted in an August 2020 paper by the Georgetown University's School of Foreign Service think tank, the Centre for Security and Emerging Technology, China "fully utilized artificial intelligence to not only research, analyse, and forecast COVID-19 trends and developments, but also to track infected persons, identify risk groups, and facilitate the resumption of normal business operations." It highlighted that China was expected continue to prioritize the development of healthcare-related AI well beyond the scope of COVID-19.[77] One early method of testing patients for COVID-19 in China made use of the Tianhe-1 supercomputer to apply AI to diagnose patients from chest scans, which was able to analyse hundreds of images in seconds and advise doctors accordingly. The results were particularly useful to help medical professionals in areas with limited test kits or suffering a sudden increase in suspected cases to quickly distinguish between patients with COVID-19 and those with common pneumonia or other illnesses. The AI was notably able to 'learn' as it received more samples and improve its accuracy accordingly, and could perform the fifteen-minute job of an experienced doctor in around ten seconds. The use of chest scans to diagnose patients had first been proposed by doctors on the frontlines when the virus first broke out.[78]

The benefits of China's investments in becoming a world leader in AI went far beyond advances in testing. The COVID outbreak demonstrated just how

useful and versatile the new technology was for a wide range of purposes, and provided a strong indication as to how it could become a major force multiplier for the wider economy. As noted by the *South China Morning Post:* "In China, AI is being used to fight the virus on all fronts. With its ability to learn quickly, AI saves humans time in sequencing the genome of Sars-CoV-2 [the virus that caused COVID-19], designing lab tests, analysing CAT scans and making new vaccines . . . AI is being used to fight the virus on all fronts, from screening and diagnosis to containment and drug development," with the effect of "greatly reducing the number of deaths." While in 2002 following the SARS outbreak scientists had to wait months before they knew what the viral genome was, in 2020 a virus' genome could be sequenced in a small fraction of the time using AI—with the genome then published and shared with researchers around the world in early January. The *Post*'s report concluded: "In the face of a sudden onslaught from COVID-19, China's ability to adapt and fight back with AI is evidence that the country's investments in artificial intelligence and related technologies are paying off. This is truly the first time AI has been used so extensively to combat an epidemic. Without AI, the spread of the novel coronavirus would have been much quicker and more devastating."[79]

Testing for COVID-19 posed a further challenge, since as a single-strand RNA virus it was highly susceptible to mutation. The Damo Academy research institute solved this by developing an AI algorithm that powered a whole-genome detection platform, which was faster and more efficient than the traditional nucleic-acid approach that detected only part of a genome. This allowed for testing in just thirty minutes with a high degree of accuracy, and by mid-February could complete the disease recognition process within twenty seconds which was a major achievement in the early stages of combatting the virus. Tech giant Baidu open-sourced its LinearFold AI algorithm that predicted viruses' RNA structures and allowed scientists to better understand how the virus invaded cells. This was not only useful for vaccine development, but also reduced prediction time from fifty-five minutes to just twenty-seven seconds.[80] AI was also used to predict the virus' immunogenic landscape, which was particularly important for developing vaccines and for avoiding potential harmful effects that they could have.[81]

On the front lines AI chatbots simulating and processing human conversation reduced pressure on hospital and government personnel by automatically answering queries from members the public, calling people deemed at high risk and helping monitor the virus' spread. The bots advised individuals about whether they needed to undergo screening in hospital or stay at home for a fourteen-day quarantine. Self-navigating robots such as Shanghai Mumu Robot's 'Noah Bots' and Keenon Robotics' meal delivery robots, using technologies frequently applied in restaurants and factories in China, were also

used to disinfect wards, deliver food and medication and check body temperatures. This reduced the workload and risks for the limited numbers of medical personnel available.[82] Beyond the confines of healthcare facilities, the tech giant Baidu developed AIs connected to and directing infrared sensors on the foreheads of moving passengers to detect their body temperatures—providing a more practical solution than manual checks. Tech firms Qihoo 360 and NoSugar Tech simultaneously introduced a platform dependent on AI technologies that organized publicly available data to allow users check if while travelling they had been exposed to anyone who contracted the coronavirus.[83]

The importance of AI's role in bolstering China against COVID-19 was widely recognized and referred to in the State Council's June 2020 White Paper. While the US claimed to rival China in AI, and other competitors such as Britain published more AI papers per capita, no other country was able to practically apply the technology in anything remotely resembling the way China did to contain COVID-19. "The pandemic provides a telling illustration of America's and China's relative strengths," an article by the editorial of the *MIT Technology Review* observed in October 2020, concluding that the stress it placed on both economies indicated: "China is catching up to the US as an inventor and leaving it in the dust as a manufacturer. This is a good thing for the world as a whole; more competition means more sources of new ideas. But the US's position in such a world is looking increasingly weak."[84] Nowhere was this clearer than in AI, with America's ability to practically apply the technology to counter the virus being negligible by comparison. The response to the virus served as an important indication of a key Chinese advantage in AI—that it was not only researching but also implementing new technologies for the public and economic good in a way that rivals appeared unable to.

A WHOLE NEW WORLD: IMPACTS OF ARTIFICIAL INTELLIGENCE

In June 2017, at the World Economic Forum's annual meeting, the London-based Pricewaterhouse Coopers professional services network launched a report on the importance of AI in the global economy. It projected that artificial intelligence would add $15.7 trillion to global GDP by 2030, equivalent to 14 percent, and that China would benefit disproportionately highly with AI adding 26 percent to its own GDP. North America would only see 14.5 percent added to GDP, a little above the global average, while Latin America and Africa were expected to see only around 6 percent added. These discrepancies largely reflected differences in rates of AI technology adoption. Leader of artificial intelligence at Pricewaterhouse Coopers, Anand Rao,

stated regarding the findings: "The analysis demonstrates how big a game changer AI is likely to be—transforming our lives as individuals, enterprises and as a society,"[85]

Dublin-based Accenture plc, a leading global provider of consulting and processing services, highlighted in its own research published in July 2017 that AI was expected accelerate China's annual economic growth rate from 6.3 percent to 7.9 percent by 2035. It highlighted that AI could boost China's gross value added (GVA) by $7.11 trillion by 2035, and had the potential to boost China's labor productivity by 27 percent by that year. Chairwoman of Greater China operations, Chuan Neo Chong, stated to this effect: "China has already made great leaps in the development of AI and our research shows that [AI] has the potential to be a powerful remedy for slowing growth."[86] Growing investment in the field globally was reflected in the solid and at times soaring valuations enjoyed by makers of AI chips such as China's Horizon Robotics and Cambricon[87] and America's Enflame.[88]

Former Greater China president of Google and founder of venture capital firm Sinovation Ventures, Lee Kai-fu, was one of several experts to draw attention to the fact that AI would bring profound economic imbalances. It would primarily do so by enriching China and the United States, which both had a massive lead in the field over the rest of the world, and increasing the economic discrepancy between them other countries. "Most of the wealth created by AI will go into the US and China because of their big pool of talent and [high levels of data generation], as well as the size of their markets," he stated to this effect.[89] AI was highlighted as an effective solution to the potential economic fallout from low birth rates in developed countries, which tended to suffer from greater population decline than non-developed ones, and this was particularly evident in China where automation of sectors such as factories, retail and public transport reduced the fallout a lack of growth in the workforce could have.[90]Adoption covered multiple very different sectors, from children's education where AI was already being used from the mid-2010s to help compensate for teacher shortages,[91] to public transportation with China's first autonomous taxi line making their debut in December 2020.[92] This was followed by the country's first autonomous bus line in April 2021,[93] a year which also saw the debut of autonomous mobile catering vehicles as competitors to restaurants and street vendors.[94] McKinsey estimated that AI could take the jobs of up 220 million Chinese workers between 2018 and 2030, or 30 percent of the workforce, which would allow labor to be reallocated to other sectors of the country's fast growing economy and ensure that a labor shortage would not impede growth rates.[95]

While the US had long heavily compensated for population decline and kept labor costs down by allowing mass low and medium skilled migration, AI provided a potential alternative which could have a less damaging impact

on social stability.[96] The structure of the American economy, however, and the country's much lower economic growth rates, meant that a rapid rise of automation caused by AI threatened to cause major problems by drastically increasing unemployment rates, creating surplus labor and lowering wages at a far faster rate than growth rates could accommodate. President Obama highlighted in an interview in August 2016 regarding AI's potential impacts on the American workforce, as it became increasingly clear that advances in the technology over the next fifteen years would drastically reduce the number of low and medium skilled jobs available:

> It could increase inequality. It could suppress wages . . . historically we've absorbed new technologies, and people find that new jobs are created, they migrate, and our standards of living generally go up. I do think that we may be in a slightly different period now, simply because of the pervasive applicability of AI and other technologies. High-skill folks do very well in these systems. They can leverage their talents, they can interface with machines to extend their reach, their sales, their products and services. Low-wage, low-skill individuals become more and more redundant, and their jobs may not be replaced, but wages are suppressed. And if we are going to successfully manage this transition, we are going to have to have a societal conversation about how we manage this. How are we training and ensuring the economy is inclusive if, in fact, we are producing more than ever, but more and more of it is going to a small group at the top? How do we make sure that folks have a living income?[97]

With China's middle class and PhD talent pool fast growing, a shift in the labor force toward a greater emphasis on high skilled workers was precisely the opposite of the trend seen in the US where the middle class was declining. It meant that the former economy was much better positioned to thrive in the new AI-dominated world than the latter. In a December 2016 paper published by the Executive Office of the President of the United States, titled: 'Artificial Intelligence, Automation and The Economy,' the trend toward an elimination of demand for low skilled labor was further drawn attention to. This was shown to be a continuation in broader trends from the mid-late twentieth century, where occupations entailing easily programmable tasks "such as switchboard operators, filing clerks, travel agents, and assembly line workers" were eliminated. AI would make redundant a very considerably wider the range of occupations performed by less skilled or less educated workers.[98] As automation in the latter half of the twentieth century fueled unemployment, AI was expected to take this far further.

A study published in 2013 by researchers at Oxford University predicted that 47 percent of human jobs in the United States were "in the high risk category" for being made redundant in the medium term, although other estimates placed this figure considerably higher.[99] "Wages and educational

attainment exhibit a strong negative relationship with an occupation's probability of computerisation," it concluded, with fields including transportation and material moving, manufacturing, farming and sales being among the most likely to be affected.[100] A Brookings Institution report in January 2019 gave a more modest assessment predicting that AI would displace 36 million US jobs by 2030—approximately a quarter of the workforce.[101] Some early examples of AIs that could displace simpler jobs would include self-driving taxis and chauffeurs, industrial and warehouse robots, self-checkout kiosks, computerized hotel concierges, self-ordering takeaway machines and robot-assisted kitchens. On the other hand, widespread implementation of AI had the potential to lower prices and create more high-skilled jobs. Beyond the US, a study by UBS Wealth Management in 2017 showed that AI would put up to 50 million jobs across the Asian continent at risk, with manufacturing expected to be hit much harder than services.[102] 50 million was a very conservative near-term estimate.

For the US, President Obama highlighted that a "universal income" could be a solution as low and medium skill level jobs disappeared at an accelerating rate. He warned regarding AI that "the social compact has to accommodate these new technologies, and our economic models have to accommodate them." This would curb the fallout from the seemingly inevitable surge in unemployment, but would also likely drastically reduce social mobility as large segments of the population would lose the opportunity to better themselves and improve their positions through work.[103] As president of the Future of Life Institute, Max Tegmark, remarked when addressing the momentous impact AI would have on labor markets: "Maybe we need to let go of the obsession that we all need jobs."[104]

The AI revolution promised not only lower social mobility for the individual, but also a drastic decrease in the mobility of relative state power and development. While China had managed to modernize its tech sector to a peer level with the Western world in approximately seven decades after 1949, and the USSR had come close to doing so in approximately two decades from the late 1920s, the possibility of others bridging the gap with the leading high tech centres of the developed world would diminish exponentially in future. AI promised to significantly accelerate the pace of development for already advanced countries such as China and the US which could invest in it from an early stage. Furthermore, both would be well positioned to use the AI they initially pioneered to accelerate the development of more capable artificial intelligence, which in turn could be used for the same ends itself once developed. Thus not only would the gap between the rest of the world, and the US and China as a 'G2' of AI elites, grow faster, but the difference between developed and underdeveloped countries would also grow much faster than it had in the twentieth and early twenty-first centuries. This had very significant

economic, strategic and military implications. Beyond the extraction of resources, and provision services such as tourism and entertainment, could the third world and its cheap, large but overwhelmingly low skilled labor forces retain any significant place in the global economy after AI began to be more widely used?

AI AND DEFENSE

Beyond its ability to provide a potentially decisive economic advantage, dominance in AI also had very significant security implications with technologies highly applicable to military modernisation in a number of ways. Some of these applications which were more benign, although still potentially very valuable, ranged from processing data from surveillance[105] to assisting with pilot training, command and control[106] and helping to check hardware for problems during maintenance.[107] AI had the potential to perform these functions more efficiently, with less room for error, and at a much lower cost than human personnel could. AI could replace human personnel in simpler more menial jobs first,[108] significantly speed up tasks from administration and logistics to surveillance and targeting, and for more dangerous jobs such as bomb disposal could reduce risks of human casualties by performing them. More aggressive applications of AI included replacing human combatants on both cyber and physical battlefields. These ranged from an AI hacker used in cyber warfare to break into enemy systems, or to defend one's own systems from attack, to piloting combat aircraft or driving tanks into battle.[109]

Tests of AI combatants already began to demonstrate tremendous potential by the late 2010s, with Tesla and SpaceX CEO Elon Musk announcing in February 2020 at the Air Warfare Symposium that as a result of the latest advances "the fighter jet era has passed." "Drone warfare is where the future will be. It's not that I want the future to be—it's just, this is what the future will be," he stated, stressing that the Air Force's latest stealth fighters "would have no chance against" upcoming drone fighters flown by AI.[110]Although Musk's comments were hotly disputed[111] by Western defense experts,[112] experiments conducted by the US Air Force later that year showed that the viability of manned combat aircraft for many roles could be greatly diminished by AI. In August the US Air Force pitted a top pilot of the F-16 Fighting Falcon—by far the most widely use fighter by America and its defense clients—against an AI pilot in five simulated air-to-air battles. The test was a culmination of a DARPA effort to explore how artificial intelligence and machine learning could help to automate various aspects of air-to-air combat. The AI pilot won overwhelming victories in all rounds.[113]

By early 2021, DARPA had AI-piloted F-16s simulating working in teams and engaging targets at longer ranges, which were major steps toward moving away from simulations and toward actually flying F-16s with AI pilots. Colonel Dan Javorsek, the program manager in DARPA's Strategic Technology Office, noted that: "Adding more weapon options and multiple aircraft introduces a lot of the dynamics," and among other things allowed developers to "assess how the AI agents handle clear avenues of fire restrictions set up to prevent fratricide."[114] Similar developments were seen in China where the air force conducted similar tests pitting human fighter pilots against AIs and finding that the latter could consistently win overwhelming victories. Chinese AIs were similarly reported to be learning from pilots, gaining experience and improving quickly[115] AI piloted fighters had the benefit of being able to learn from simulations much better than human pilots could, meaning the costs of regularly flying combat aircraft for training purposes would be eliminated if they were full autonomous. This had tremendous implications for how air forces operated, as the primary cost of any combat aircraft was not the price of acquiring it but rather of flying and operating it over several years. Without the need for training flights, costs could be cut sharply which in turn could facilitate fleets which were much larger than those seen in the era of human pilots.

Without support from the Chinese or American AI sectors, other military aviation manufacturers such as Russia or France were set to fall considerably further behind in the capabilities of their aircraft. Artificial intelligence could 'experience' millions of hours of simulated combat and 'learn' from this experience 24/7—as much as AlphaGo had done with Go to improve itself rapidly before beating Lee Sedol in 2016. An AI pilot could supplement this experience by bringing together data in aerial combat much faster than a human could, and use this to come up with an optimal means of neutralising targets. While the flight performance of combat aircraft was limited by human pilots' inability to endure a g force from high manoeuvres of over 9g, an AI piloted aircraft could be as manoeuvrable and fast as a missile and pull turns at 40g or more. Moreover removing the life support systems and interfaces needed by human pilots, which took up considerable room inside each fighter aircraft, could contribute to making AI-piloted fighters of the future considerably lighter and more efficient.

A stepping stone to a fully autonomous fighter aircraft was a synergy between a human pilot and an AI, either serving as co-pilots in a single aircraft or flying alongside one another. A notable sign of the former development was the scarcity of twin-seat post-fourth generation fighter aircraft, which was widely seen as a result of early AI having made the weapons systems officers in the second seat redundant. A notable exception was the development of fifth generation fighters for command and control, with the

second seat accommodating an officer who would integrate with autonomous drones and coordinate attacks, which China pioneered with the J-20S stealth fighter which first flew in October 2021.[116] AI co-pilots were compared by the US Air Force's Assistant Secretary for Acquisition, Technology and Logistics Will Roper to R2D2 from the Star Wars franchise,[117] with the chief designer of the J-20 Yang Wei highlighting that they could help pilots process vast information and make decisions in complex battlefield environments.[118] Less advanced AI assistants could also be used to aid novice pilots in becoming accustomed to their aircraft and pointing them to important information, as seen with the relatively basic AI on Russia's MiG-35 fighter.[119]

The trends seen in fighter aviation applied to varying extents across the spectrum of military modernisation. China, for example, invested in converting a portion of its surplus fleet of thousands of Type 59 tanks into unmanned combat vehicles benefitting from AI. Developing technologies for advanced fully autonomous tanks, which would allow the army to operate very large armoured units of new vehicles and potentially reduce crew requirements for future manned tank designs, were raised as possible outcomes of this program.[120] Many similar kinds of investments in using AI for military purposes were made in both China and the US, with the latter developing AI tools for sensors and navigation,[121] for autonomous aerial resupply missions,[122] and for cyber offensives.[123] One example was a US Air Force program to allow attack jets to find targets faster by filtering out bad information using AI.[124] Another was an expendable unmanned missile launcher designed to harass enemy ships and air defenses.[125]A third was an Air Force program to take over the sensor suite of a long-range surveillance aircraft. Secretary Roper noted regarding the latter landmark test in December 2020: "Putting AI safely in command of a US military system for the first time ushers in a new age of human-machine teaming and algorithmic competition. Failing to realize AI's full potential will mean ceding decision advantage to our adversaries."[126]

Among the AI weapons perceived as leading potential threats to US security were increasingly sophisticated AI cyberweapons, drones armed with AI software smart weapons to target infrastructure, and AI-enabled "weapons of mass influence" designed to sow discord among the enemy populace.[127] Advances in cyber warfare and the increasingly network-centric way militaries fought meant that breaking into weapons and equipment to sow confusion and misinformation, shut them down or even turn them against their operators was often much more efficient than physically destroying them. To this end, AI's ability to provide a decisive advantage in cyber warfare was highly valued.[128] As NSCAI chair Eric Schmidt warned in 2020: "you can imagine if some new AI technique were invented by our opponents that could be used for cyber war in a way that we did not anticipate. That would be really bad."[129] This was a situation both China and the US invested very heavily to avoid.

Despite significant investments, and military applications of AI receiving a disproportionate amount of attention and funding in the United States, the Pentagon faced considerable difficulties attempting develop and utilize AI for military purposes. The aforementioned NSCAI report from March 2021 noted regarding these issues that "visionary technologists and warfighters largely remain stymied by antiquated technology, cumbersome processes, and incentive structures that are designed for outdated or competing aims." It further highlighted regarding the integration of AI into the military and defense sector:

> The obstacles to integrating AI are many. DoD [Department of Defense] has long been hardware-oriented toward ships, planes, and tanks. It is now trying to make the leap to a software-intensive enterprise. Spending remains concentrated on legacy systems designed for the industrial age and Cold War. Many Departmental processes still rely too much on PowerPoint and manually driven work streams. The data that is needed to fuel machine learning is currently stovepiped, messy, or often discarded. Platforms are disconnected. Acquisition, development, and fielding practices largely follow rigid, sequential processes, inhibiting early and continuous experimentation and testing critical for AI.[130]

Analysts at *The Drive* in early 2021 were among many others to note to similar effect regarding America's slow adoption of AI for the military: "While wars have for centuries been largely decided by which side possesses the best hardware, we are entering a brave new future in which software will hold the key to global supremacy . . . the laborious slow pace of procurement and innovation among the DoD has left the United States lagging behind in terms of its preparedness to face AI threats."[131] The importance of AI to determining the future balance of power on the battlefield was widely recognized, and while lagging far behind China and the US there was still a strong focus on development of military applications abroad particularly in South Korea[132] and Russia.[133] Indeed, reflecting a recognition of AI's potentially decisive impact, and a future of warfare in which rival fleets of unmanned autonomous drones clashed, Russian President Putin posited: "when one party's drones are destroyed by drones of another, it will have no other choice but to surrender."[134]

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Chapter 3

Competition in Emerging Technologies from Green Energy to Quantum Computing

CLEAN ENERGY AND CHINESE ECONOMIC MODERNIZATION

An area of economic modernization with fast growing importance, and where China was increasingly showing signs of dominance both in the sophistication of its firms' products and the scale on which new technologies were being employed, was environmentally friendly 'green tech.' Using technology to reduce the damage done to the environment by a fast-modernizing economy, and to ensure that development could be made more sustainable, had been a major focus of the country's ruling party particularly since 2011. The twelfth Five-Year Plan initiated that year laid out plans for major efforts to tackle climate change which emphasized lower carbon dioxide emissions per unit of GDP and investments in environmentally friendly power generation.[1]

The gaseous compound carbon dioxide, which is released when fossil fuels such as oil, coal and natural gas are burned to generate electricity or other forms of energy, accumulated in the atmosphere over hundreds of years to create a 'greenhouse effect.' By increasing the Earth's temperature this threatens to cause both more extreme weather and serious damage to key ecosystems, which in turn could put at risk the future of human civilization. Fossil fuels are relied on to provide the vast majority of electricity across the world, and also power combustion engine vehicles such as cars, ships and aircraft. While the need to reduce carbon dioxide emissions globally has long been widely recognized, slow action on the part of major industrial countries allowed China to emerge as a leader in the push toward development and

adoption of cleaner more sustainable means of power generation. Green energy has the potential to increase China's economic self-reliance by eliminating dependence on foreign energy sources such as fossil fuels, while also ensuring that the country's economic development is environmentally sustainable, improving standards of living and public health, and providing opportunities for export of green technologies.

Due to concerted government efforts to create a more environmentally friendly economy, the increase in Chinese carbon emissions remained very modest from 2011 relative to the rate of economic growth. China's share of global carbon dioxide emissions notably did not increase after 2011 despite the rapid growth in the country's share of both global GDP and of global manufacturing, the former from 10 percent to 17 percent, in the following decade.[2] Looking to the targets set in 2005, the amount of carbon dioxide produced per unit of nominal gross domestic product, known as its 'carbon intensity,' fell by 46 percent in twelve years leading up to 2017, which far exceeded the goal of 40–45 percent by 2020. By 2017 non-fossil fuel energy consumption had risen sharply to 13.8 percent, with the goal of 15 percent by 2020 comfortably surpassed three years later.[3] As a percentage of total energy consumption coal fell by 10.8 percent from 2012 to 2019 while renewable energy, such as solar, wind and hydropower which did not rely on burning fossil fuels, increased by 8.9 percent. Emissions from remaining coal power stations were reduced considerably using new 'ultra-clean' technologies. These advances were achieved despite the rapid rate of economic growth and overall energy consumption.[4] China also very comfortably surpassed its 2020 afforestation goal of 1.3 billion cubic meters, and had already reached 2.1 billion in 2017, with larger forests absorbing and storing more carbon to help counter the greenhouse effect.[5]

By 2017 China produced 28 percent of the world's renewable energy, which made it the world leader by a significant margin. It was continuing to incrementally reduce reliance on coal in favor of cleaner forms of energy, with a 10.8 percent reduction of coal use from 2012 to 2019 alone as a proportion of total energy consumption, and remaining consumption moving to cleaner power plants. By 2019 30 percent of all clean energy in the world was produced in China, with the country leading the world in most cases by a very considerable margin in installed solar, wind, biomass and hydroelectric power.[6]

One of the earlier areas of renewable energy to receive concentrated investment was hydroelectric power, with construction plans from 2012 to 2022 stipulating the completion of five of the world's 10 largest hydropower plants within that short period. By 2017 the country's dams were already generating more electricity than those of the rest of the world combined excluding the US and India. From 2000 to 2019 China more than quadrupled its installed

hydropower capacity and accounted for the majority of all global hydropower growth.[7] The dams provided an effective means of controlling flooding, which had been a major cause of food shortages for millennia of Chinese history, and allowed the country to significantly reduce reliance on fossil fuels. 2021 saw the world's first giant hydropower turbines activated at the sixteen-gigawatt Baihetan station, which was hailed by the country's leadership as a major breakthrough for Chinese high tech manufacturing and seen by analysts as an important step toward reducing reliance on fossil fuels.[8]

Despite its successes, growth in China's hydroelectric power industry slowed considerably by the end of the 2010s. There were three primary reasons for this, the first being that the sites suitable for major new hydroelectric dams with large flows of water cascading down a steep change in altitude had increasingly been exhausted. The second was the environmental and social costs of building such dams, as although they provided clean energy they still often displaced large numbers of people and were detrimental to some forms of local wildlife. A notable example was the endangered giant salamander, which was adversely affected by the construction of dams Hunan Province leading the Chinese government to demolish ten dams entirely to protect the species and to consider further demolitions.[9] The third reason was the growth in efficiency of competing forms of renewable energy following years of concentrated effort in research and development, which increasingly appeared to be the future of renewables in China with more promise than dams.

One major area of investment in China's drive to increase reliance on renewable energies was wind power, with increasingly efficient turbines constructed across the country's desert regions and at sea meeting a growing portion of its energy needs. By 2018 over a third of wind turbine manufacturers in the world were based in China, with the scale of the country's investments dwarfing those of any other and placing it at the forefront of global growth in the industry. This was particularly remarkable considering its status as a developing country and its much lower per capita GDP than its Western competitors, as wind power like most renewables was much less cost effective than fossil fuels meaning the government was paying a great deal for the benefit of the environment. As *The Guardian* observed in August 2020, citing the Global Wind Energy Council: "The world's offshore wind farm capacity could grow eightfold by the end of the decade powered by a clean energy surge led by China."[10] The country had that year built more new wind farm capacity than the whole world combined—an increase of 60 percent from the previous year.[11] The following year Chinese firms made up seven of the world's ten top manufacturers of wind turbines.[12]

In September *Wired* had observed that China was "building a world-beating wind energy revolution" which would "provide enough energy to power millions of homes and businesses." It stated regarding this:

> China has been steadily building up its wind farms over land and sea. Despite Covid-19 grinding much of the world to a halt, China's drive to conquer the global renewable energy market continues apace: it's constructing more offshore wind capacity than the rest of the world combined. Since reaching the one-gigawatt milestone in 2017 (enough energy to power 100 million LED home light bulbs), progress has been rampant. China is now the world's leader in new offshore wind installations. By 2030, it's expected to reach a 52-gigawatt capacity.[13]

While China's investments in wind power had yielded significant results, investments in solar power were seen to hold more promise and had the potential to revolutionize the global energy industry. Adoption of solar energy had for years benefited from significant government subsidies and led China to emerge as the undisputed world leader in the field which by 2018 was generating 130 gigawatts (GW) from solar power. This comfortably exceeded the target of 110GW by 2020. The rate of construction of new solar farms was also growing, with more than 34GW of solar capacity added in 2016 alone and approximately 53GW added in 2017.[14] Over 60 percent of solar panels in the world were manufactured in China by that time, rising to almost 80 percent in 2019, and while many of these were for export the bulk of orders were domestic.[15] Arguably much more important than the scale of adoption of solar energy, however, was the considerable and sustained investment in research and development to improve the efficiency of solar farms. Chinese research teams continued to lead the world in setting new records for how efficiently sunlight could be turned into electricity including development of organic photovoltaic cells made from carbon and plastic, which were cheaper and easier to manufacture and recycle, as well as improving conventional silicon-based cells.[16]

China's solar industry had started to reach grid parity in early 2019, with concerted R&D investments leading to multiple major breakthroughs in the photovoltaic sector which for the first time made solar energy prices competitive against fossil fuel generated electricity.[17] The implications of this were very significant particularly considering how inefficient solar power had been just ten years prior, with the rate of advances in efficiency raising the possibility of solar farms becoming a more economic option than fossil fuels across much of the world. While solar energy had been adopted to a limited extent largely due to its carbon neutrality, and to the fact that it was often given tax benefits relative to fossil fuels, getting free market forces behind it by making it price competitive against fossil fuels would very likely result in a rapid acceleration of its adoption globally. The cost effective solar energy that could result from Chinese advances in efficiency had the potential to solve many of the world's pressing problems—for example reducing growing water

shortages in many parts of the world by making desalination of sea water much more affordable through inexpensive sustainable energy.[18]

China's massive global lead in embracing renewable energies was totally undisputed by the mid-2010s, and by 2018 its consumption of these energies was 38 percent higher than the US and triple that of Germany. Consumption of renewables grew by 25 percent annually throughout the late 2010s which placed China on course to depend on them for a full 20 percent of its total energy consumption by 2025.[19] "No country has put itself in a better position to become the world's renewable energy superpower than China," noted a 2019 report by the Global Commission on the Geopolitics of Energy Transformation—a group chaired by a former president of Iceland Olafur Grimsson and set up by the International Renewable Energy Agency. It highlighted that countries which were heavily reliant on fossil fuel exports such as Russia and Arab gulf states were expected to suffer serious economic losses, and possibly serious challenges to political stability[20] as a result of the major advances by China in developing more efficient renewable energies.[21] By 2016 China already had well over 150,000 renewable energy patents, which represented 29 percent of the global total. Its lead and the proportion of patents it had continued to increase in the following years. Citing the report's figures, *Forbes* noted that China had "a clear lead in terms of the underlying technology."[22] Founder of the energy research consultancy Cambridge Energy Research Associates Daniel Yergin observed to similar effect in 2020: "In green energy, China has already reached the 'Made in China 2025' goal of a dominant role in this century's new industries."[23]

Among many sources in the West to assess China's lead in renewable energy through a paradigm of geopolitical competition, *Foreign Policy* reported in late 2020: "Beijing is winning the clean energy race. The technology to build new green economies is mostly produced in China. That's bad for the United States." It noted as an example that by 2019 China generated twice as much wind and three times as much solar power as the US.[24] Geopolitically, supporters of Western primacy and dominance often perceived China's successful initiatives to improve the environment by investing in green technologies as negative. China's commitment to a greener future and reduced carbon emissions, however, benefited the entire world including the United States by pushing back against climate change. By contrast, there was little dispute from the scientific community that highly polluting developed countries such as the US[25] and Australia[26] which were much better positioned to fund a transition to renewable energy, but notably neglected to do so, were harming the wider world including both China and themselves.[27]

As part of broader efforts to reduce reliance on fossil fuels China invested heavily in pursuing advances in nuclear energy in parallel to its investment in renewable energy. In September 2020 the country's State Power Investment

Corporation announced that the development of CAP 1400 third generation nuclear technology had been completed. The technology had been under development since 2008, and by August 2020, 1,052 patents and 6,513 intellectual property applications had been registered in connection with it. Successful development of this technology domestically was expected to help facilitate serious cuts to carbon emissions, with each reactor built using it able to cut greenhouse gas emissions by over 9 million tonnes and meet the average annual energy demands of over 22 million people.[28]

A safety review in China following the 2011 Fukushima nuclear plant disaster in neighboring Japan led to a greater emphasis on developing third generation nuclear technologies, which had a risk of serious accidents 100 times lower than second generation reactors and were designed to last sixty years.[29] The new reactors had reduced maintenance and capital costs, passive nuclear safety measures such as passive core cooling systems, and improved fuel technology and thermal efficiency. China already had an excellent safety record with the older technologies. The new technology placed China on par with leading players in the field, and observers hailed the development as potentially heralding a boom in the country's nuclear power industry.[30] The country was projected to construct 6–8 new nuclear reactors per year in the first half of the 2020s, and to see demand for foreign reactors effectively collapse.[31] Dean of the China Institute of Energy Policy at Xiamen University, Lin Boqiang, was one of many to highlight that nuclear power would play an important role in helping China attain carbon neutrality, and could serve as "the source of baseload electricity to gradually phase out coal."[32] Developing a self-reliant nuclear industry also had considerable strategic benefits, with the China General Nuclear Power Group having been targeted by US sanctions from 2019 and future support for the operation of Western-designed reactors in China far from certain. With a particularly robust nuclear energy supply chain the domestic nuclear industry would not be reliant on imported components or expertise, or on imported fossil fuels, and would thus bolster China's energy security.[33] From the world's third largest nuclear power generation capacity at the beginning of the 2020s, China was expected to account for close to half of all nuclear power generation by 2035 and to double this figure again by 2060.[34]

A notable experimental nuclear energy program, the world's first Thorium-fueled molten salt reactor at Wuwei on the outskirts of the Gobi Desert, began test operations in September 2021. The reactor worked at much higher temperatures, produced considerably less radioactive waste, was potentially much cheaper than traditional uranium-fueled reactor designs, and could be built in otherwise unused desert areas as it did not use water for cooling. With Thorium being far more readily available than Uranium, as a waste product of domestic rare-Earth mining, the strategic value of its

potential utility for power generation was also considerable. It was expected to be well over a decade before the technology was commercially viable, with the small Wuwei reactor producing only two megawatts of energy. If successful, however, it could pave the way for multiple new facilities before 2040—a goal which was highlighted as an important milestone toward achieving carbon neutrality by 2050. Several other experimental nuclear energy programs were being pursued in parallel including reactors cooled by lead or sodium liquids.[35]

As part of a much more ambitious and potentially revolutionary program, in December 2020 China turned on it first nuclear fusion reactor the HL-2M Tokamak. Using similar nuclear reactions to those seen on the sun, fusion reactors could potentially produce orders of magnitude more power than standard fission reactors. While the USSR and US had led the drive to move from fission to fusion based nuclear weapons in the Cold War, providing hundreds or even thousands of times as much destructive force, China was well placed to lead the world in fusion-based nuclear energy in the twenty-first century. Such an energy source was extremely challenging to harness, and while identified as theoretically possible it had been too difficult to attempt since the dawn of the nuclear age. The Chinese reactor used a powerful magnetic field to fuse hot plasma and could reach temperatures of over 160 million degrees Celsius—approximately ten times hotter than the core of the Sun.[36]

This experiment's success represented a significant step toward providing China with complete energy independence, as the amount of electricity which could theoretically be generated was well beyond anything the world had seen—described as an "almost limitless" clean energy supply. The state-run *People's Daily* news outlet reported regarding the test: "The development of nuclear fusion energy is not only a way to solve China's strategic energy needs, but also has great significance for the future sustainable development of China's energy and national economy."[37] The reactor reached a new landmark in May 2021 when it sustained extreme temperatures for five times longer than its previous record and thereby set a new world record.[38] In December it broke further ground with a record 1056 second run time and 70 million degree temperature 467 percent that of the sun's core.[39] It was expected that at the existing rate of progress commercial use of fusion energy could begin as early as 2050, with work on the China Fusion Engineering Test Reactor (CFETR) beginning in 2021 and expected to take up to ten years to complete.

CHINA'S ELECTRIC VEHICLE REVOLUTION

In parallel to large scale investments in clean energies, Chinese investments in electric vehicles were unparalleled worldwide. Under the Fourteenth Five-Year Plan China's State Council forecast in 2020 that electric cars would rise from 5 percent to 20 percent of all new car sales by 2025, with the government set to support technological improvements to make the vehicles more efficient and easier to use. It was also set to improve the green car quota system to guide automakers to make more environmentally friendly vehicles.[40] The Ministry of Industry and Information Technology had previously set a more ambitious goal of electric cars comprising 25 percent of new sales by 2025.[41] Developments in the industry, including the launch of very low cost electric cars by China's top automaker SAIC Motor, meant that reaching or exceeding the 25 percent goal was a real possibility.[42] An indicator of China's lead in the field was that as of 2020 107 of the 142 lithium-ion battery megafactories under construction globally (75% of them) were to be built in China—compared to just nine in the US (6.3%)—with these batteries being key to powering a new generation of more efficient electric cars.[43] Another was the 2020 White House figures which showed that China had 800,000 charging stations for electric cars compared to just 100,000 in the US, indicating that China was not only producing but also using such vehicles on a far greater scale.[44] The extent and importance of the Chinese lead in electric vehicles was such that stemming the trend was highlighted as a policy priority by President Joe Biden just four months after taking office.[45]

Major success stories in the private sector were frequent, with a six-year-old Chinese electric vehicle startup Nio surpassing America's biggest car producers the 116-year-old Ford and the 112-year-old General Motors in value in 2020. The firm produced high end electric vehicles which competed in the same price range as Tesla, and were rapidly gaining market share while its American rivals' market growth in China remained sluggish. Nio's rise in the stock market primarily came not because it was particularly profitable or produced a very large number of cars, but rather as a result of general faith from investors in the future of the Chinese electric car industry which benefited all major producers' share valuations.[46] The growth in Chinese electric car brands led to rising expectations that, after capturing more of the domestic market share, they would begin to compete more aggressively in export markets against Western firms such as Tesla. Western competitors were increasingly seen to be at risk of lagging behind in technology and cost effectiveness, with Tesla's ranking slipping against leading Chinese brands such as BYD and Xpeng.[47]

In November 2021 Chinese automaker GAC Group unveiled the world's first mass production electric car able to travel over 1000km, the Aion LX Plus,[48] with Chinese technological leadership increasingly apparent in the growing demand, most notably from Japanese auto giants, for large technology transfers to improve their own vehicles.[49] Founder of the energy research consultancy Cambridge Energy Research Associates Daniel Yergin was one of many to observe regarding China's key advantages in the field: "China's leadership in EVs could give it global leadership in electric vehicles in the global marketplace."[50] *Forbes* in April 2021 highlighted that Nio's low cost electric 'minicar,' the FreZe Nikrob EV, had the potential to "spur Europe's electric car mass market," with a comfortable advantage over all other electric vehicles in the market. Costing just $12,000 after tax, its practical design had an impressive performance considering its price range which led many to see it as the ideal 'city car.'[51]

Leadership in the market and establishing a global market share early on was particularly prized due to the electric car industry's very promising future. Falling battery prices, improving energy density, the construction of more charging infrastructure, and the opening of new markets, all served to facilitate a rise in passenger electric vehicle sales worldwide from 450,000 in 2015 to 2.1 million in 2019, with the rate of market growth set to continue to increase rapidly. A rise in average battery energy density of 4–5 percent annually, higher charging speeds, and an 87 percent fall in the price of lithium-ion battery packs from 2010 to 2019 were among the factors that led experts to predict that even when excluding tax incentives, they would reach up-front price parity with internal combustion vehicles in most segments by around 2025. Global sales were expected to reach 8.5 million by 2025, 26 million by 2030, and 54 million by 2040, with the share of new car sales globally represented by electric cars rising from 2.7 percent in 2020 to 10 percent in 2025, 28 percent in 2030 and 58 percent in 2040. The number of electric cars in use globally was expected to rise from 8.5 million in 2020 to 116 million in 2030, according to an assessment of markets made in 2020.[52]

Chinese government regulations further provided firms with a strong incentive to increase production of, and therefore marketing for, electric vehicles. In 2019 each Chinese vehicle manufacturer and importer building or importing over 30,000 vehicles in China was required to build or import at least 10 percent electric vehicles. This increased to 12 percent in 2020. Those which failed to reach the required percentages could purchase credits from companies that over complied, which provided a further benefit to manufacturers more focused on electric car production in the form of revenues from credit sales.[53]

By the mid-2010s China's electric car market was well over twice the size of any other and in 2017 it enjoyed sales of over 770,000 of a global

1,220,000—or around 63 percent of all global sales. The EU and US had around 200,000 each. China's lead continued to grow rapidly as the rate of growth in demand far exceeded that in the West.[54] Citing a 2020 study by the climate think tank Carbon Tracker, *Reuters* noted regarding the consequences: "An aggressive China-led shift to electric vehicles is expected to slash global oil demand growth by 70 percent by 2030 and will help bring an end to the 'oil era.'"[55] The report projected that China could save more than $80 billion annually in oil import costs within a decade as electric vehicles became more efficient and competitive. It claimed its calculations were based on the conservative projection of the International Energy Agency that electric vehicles would account for 40 percent of China's total car sales by 2030. As Carbon Tracker strategist Kingsmill Bond noted: "This is a simple choice between growing dependency on what has been expensive oil produced by a foreign cartel, or domestic electricity produced by renewable sources whose prices fall over time."[56]

The shift toward electric vehicles went beyond private cars. By the end of 2018 China had 421,000 electric buses compared to just 300 in the United States, and with a massive scale of production and demand in the East Asian state it accounted for 55 percent of electric bus sales globally by 2020. By that year electrics had replaced 60 percent of the country's combustion engine busses up from 20 percent in 2015. According to some reports, electric buses had just one quarter of the per-mile fuelling costs of combustion engine busses and required less maintenance, meaning although they were more costly to build they more than compensated for this over their service lives. Government subsidies and a greater focus on lifetime costs, rather than solely on acquisition costs, played an important role in fuelling growth.[57] China's lead over the rest of the world in the field was overwhelming, with the *Wall Street Journal* noting in the headline of a prominent article that as early as 2018 it was already "the only one in the race to make electric busses, taxis and trucks." A central part of this claim was that 99 percent of all electric busses produced globally from 2014 to 2017 were produced in China.[58]

Alongside electric busses, considerable investments were also made in developing more efficient hydrogen powered busses and trucks, building networks of hydrogen vehicle refueling stations, and producing hydrogen more efficiently using wind and solar energy. Some sources predicted that 1 million such vehicles could be operating in China by 2030 as the technology became more efficient, providing another substitute to vehicles which relied on carbon dioxide emitting and mostly imported fossil fuels. Japan's Toyota and South Korea's Hyundai saw China as a leading potential user of hydrogen powered vehicles and moved to invest accordingly.[59]

Beyond busses, other investments in combustion-free public transport provided more convenient alternatives to use of energy-intensive private vehicles

and in some cases were considered alternatives to air travel. The first decade of expansion of China's high-speed railway network, which was powered entirely by electricity, was the most prominent example. The country's first high-speed railway had opened shortly before the 2008 Beijing Olympics and used a 117km route to connect the capital with nearby city of Tianjin—setting the record for the world's fastest conventional train service by top speed and reducing travel time from seventy to thirty minutes.[60] Excluding Taiwan, high-speed rail lines in China reached over 25,000km within a decade by 2017 and in 2020 reached over 35,000km, before passing 40,000km in 2021. Passenger numbers on China's high-speed rail networks consistently grew by approximately 30 percent annually from 2008 to 2021.[61]

In 2019 alone China's high-speed railway network grew by over 3,200km, with the length of line added that year being more than any other country's total rail line. The entire US high-speed rail network was under 750km—approximately two percent the length of China's. This forced Americans to continue to rely on air travel and the inter-state highways built in the 1950s and 1960s for transport which were less cost effective, much more polluting, and most often took more time than a high-speed rail line would have.[62]

To put the Chinese network's size in perspective, by 2019 it had approximately twice as much high-speed railway laid down as the rest of the world combined.[63] As noted by the *Asia Times* the following year regarding the sheer rate of expansion: "China has by some estimates crammed half a century's worth of feasibility studies, planning and construction into about a decade."[64] The program aimed to reach 70,000 km of rail line by 2035, with future lines placing a greater emphasis on connecting the sparsely populated but strategically and economically significant parts of western China to the economic heartlands near the east coast. This was expected to fuel economic growth in the western regions and reduce demand for air travel, much as it had between major cities in the east.[65] As former private equity investor Winston Mok observed, high-speed rail had the ability to "catalyse the economic development," and did so

> by connecting cities distinguished for different functions—research and development, manufacturing, commerce and finance—China is creating new kinds of mega region . . . With these trains, China is altering its geography—the once immutable factor in economic development—by compressing large physical expanses into tightly integrated space. In this way, Beijing is facilitating the emergence of vibrant economic regions—which define the competitiveness of nations.[66]

As the network grew further, China's expanses became smaller and more tightly integrated.

High-speed rail did much to reduce the carbon footprints of travelers between Chinese cities. With train stations located much closer to the city centers and the trains being more punctual and requiring less waiting time or security checks, using the high-speed rail in many cases took less time than travelling by air.[67] Second class seats on a high-speed train offered more leg room than economy class on a flight, provided internet access, and did not subject travelers to turbulence or to cancellations caused by weather as air travel at times did. A 2017 study published by the *Transportation Research* journal projected that approximately 80 percent of China's domestic aviation routes would be overlapped by high-speed rail by 2025, stating regarding its impact on demand for air transport: "We have found that the introduction of parallel high-speed rail services has a strong negative impact on the air transport demand in China, and the air passenger demand becomes much more elastic after the entry of high-speed rail."[68] A February 2021 assessment by *Simple Flying* noted to similar effect that the expansion of the high-speed rail network was "fundamentally altering how people get around and presents a long-term threat to China's domestic aviation market."[69]

For travel within cities the expansion of the underground rail networks was also considerable, with the country running seven of the world's twelve longest networks by 2017. As of that year forty-one cities were building underground lines, twenty-six of which were getting their first. New technologies allowed construction to proceed more quickly and safely, with the government heavily subsidizing construction which pushed down ticket prices and thereby made it more attractive as a competitor to travel by car. Taking the Shanghai Metro as an example of the rate of expansion, it grew from 617km of track in 2017[70] to over 743km in 2020,[71] and was expected to exceed 1000km by 2025.[72] Averaging over 10 million individual trips daily, it accounted for 53 percent of all the public transportation in the megacity of 24 million people.[73]

Although non-combustion vehicles such as high-speed trains, busses and electric cars all required electricity to power them, which was most often generated at power stations that relied on fossil fuels to do so, they were still highly beneficial for the environment. As clean energies such as solar and nuclear power became responsible for a fast-growing proportion of China's power generation, electricity generated in such ways could provide a greater share of the power used by these non-combustion vehicles meaning their advantages would only grow with time. Furthermore, even when relying on electricity generated by burning fossil fuels, use of electric vehicles was still significantly more efficient and environmentally friendly than combustion engines. Their use also concentrated carbon emissions at power stations ensuring they would not make emissions within population centers.[74]

CHINA'S VISION FOR A GREEN FUTURE

China's investments in renewable energy notably also played a major role in facilitating exports that helped other countries reduce their own carbon footprints, while earning revenues which could be invested in further research and development domestically. The Australian state of Tasmania was a notable example, and in late 2020 declared that it had become one of the very few jurisdictions worldwide to be powered entirely by renewable energy. The state had eliminated reliance on coal and gas and invested heavily in wind and hydroelectric power. Tasmania's close partnership with China in the energy sector had long been criticized in Western media, largely on ideological grounds by constructing China as the 'other' on the basis of its non-Westernized political system. Tasmania's achievements through partnership with the world's leader in renewable energy technologies were later hailed in Western press, however, while consistently failing to mention China's role as the key facilitator. With very few exceptions, whenever Tasmania's clean energy revolution was mentioned in a positive context Chinese involvement was omitted.[75] Although Tasmania's low population density and resulting modest energy needs made a transfer to renewable energies relatively easy, continued Chinese investment in improving the efficiency of these technologies increased the possibility of regions and countries with higher population densities making similar achievements in future—including eventually China itself.[76]

On September 22, 2020, President Xi Jinping announced at the United Nations General Assembly that China would "aim to have [carbon dioxide] emissions peak before 2030 and achieve carbon neutrality before 2060" as part of its efforts to scale up its contribution to the international fight against climate change. *Foreign Policy* noted that China's leadership may have "just saved the world," and had "permanently changed the global fight against climate change." "With those two short sentences China's leader may have redefined the future prospects for humanity," it stated regarding Xi's speech.[77] On the whole, however, Western media responses were highly cynical and consistently strongly implied either than China could not be trusted to keep to its pledges, or that somehow it only cared for the environment because Western pressure had forced it to do so.[78] The research consortium Climate Action Tracker assessed that Beijing's commitment could curb global warming by 0.2–0.3 degrees Celsius this century—a very considerable amount—and would represent the biggest reduction in projected global warming of any climate commitment ever made.[79] The pledge by President Xi notably followed an assessment by researchers a year prior that the way China's economy was developing, with more wealth actually driving down carbon

emissions, could allow it to reach peak carbon emissions a full ten years before the date pledged under the Paris Climate Accord.[80]

Providing further insight into how these ambitious goals would be achieved, in December 2020 China's State Council Information Office released a white paper outlining the country's new approach to energy. It stipulated: "an increased push toward diversified energy sources, especially renewable energy and nuclear power; and introducing further market forces into the energy sector in the interests of streamlining government administration." The report highlighted previous successes, including regarding figures from 2019: "China was the world's largest producer of clean energy, too, accounting for 30 percent of the world total. China leads the globe in installed solar, wind, biomass and hydroelectric power." It further noted the 10.8 percent reduction of coal use since 2012 alone, and moving remaining consumption toward cleaner power plants.[81]

While China's carbon dioxide emissions per capita on a consumption basis were far lower than those from the Western world—far behind the very high polluters the US and Australia and a little behind the European Union—the developing East Asian country with a much lower per capita GDP was willing to go to much greater lengths to preserve the environment. As *Foreign Policy* observed:

> Global warming is produced not by the annual flows of carbon but by the stocks that have accumulated over time in the Earth's atmosphere. Allowing an equal ration for every person on the planet, it remains the case that the historic responsibility for excessive carbon accumulation lies overwhelmingly with the United States and Europe. Still today China's emissions per capita are less than half those of the United States'—making China's willingness to make greater sacrifices to fix the primarily Western caused issue all the more outstanding.

The magazine highlighted that the nature of the political system in the United States, "the basics of the American way of life," and the state of public opinion toward climate change meant that, unlike in China, serious American action on the issue was not feasible.[82]

Looking to global responsibility for climate change and excess carbon emissions, a study at the University of London published in 2015 found that the United States was responsible for 40 percent of excess global emissions, with the countries of the European Union responsible for another 29 percent. China, by contrast, was within its boundary for a fair share of emissions. Climate change and the accumulation of greenhouse gasses in the atmosphere was overwhelmingly a Western-caused problem, which made China's leadership in pursuing a solution and the complacency of many Western countries in doing so all the more remarkable.[83]

Although China was arguably doing more than any other country to reduce its carbon emissions, particularly considering the size of its industry and its status as a developing country, its efforts notably consistently received negative coverage in the West. This was not necessarily due to any specific aspect of its efforts to develop a more modern, clean and sustainable energy industry, but was instead part of a much larger trend in Western coverage of positive aspects of Chinese state policies and economic modernization. As noted in the title of a 2019 article by former chairman of Morgan Stanley Asia and Yale University faculty member, Stephen S. Roach, "the West has failed to give Beijing enough credit for its green leadership," and was instead in a "rush to demonize China." He stated to this effect:

> By changing its economic model, shifting its sources of fuel, developing new transport systems and embracing eco-friendly urbanisation, China's sustainability strategy is an example of global leadership that the rest of the world should consider very carefully. In the rush to demonize China over trade, the West has missed this point altogether . . . by shifting away from carbon-intensive manufacturing to low-energy services, and embracing electric vehicles, high-speed rail and eco-friendly urbanisation—and being likely to stay the course on all these trends—China is setting a high bar for the rest of the world.[84]

Roach concluded: "China is focusing on sustainability when its per capita [nominal GDP] output is barely more than one-third that of advanced economies. A relatively poor nation has made a conscious choice to shift from the quantity to the quality of growth. The West should take note."[85]

Dale Vince, owner of green electricity company Ecotricity, was one of many to note to similar effect that there was "hypocrisy coming from the developed world" in criticizing China for its carbon emissions, with the West ignoring the rate at which it was turning to clean renewable energy which was unheard of in the developing world. "I like what China is doing . . . Without China, we wouldn't have the successful solar and renewables industry of today," he said, with the country's investments in these forms of energy accelerating their adoption globally.[86]

Complementing efforts to shift toward clean energy, China pursued both a vigorous campaign to reduce pollution and major parallel afforestation efforts which would improve air quality. Efforts to reduce pollution were manifold and often highly complementary with cumulative benefits. They frequently achieved successes in relatively short time periods that were unprecedented worldwide. Between 2013 and 2017 alone particle pollution in 74 major cities fell by an average of 33 percent, with this trend continuing in the following years.[87] The UN Environment Programme published a report in 2019 on a 20 year effort to improve air quality in Beijing which it highlighted as a good

example to the world of how "a large city in a developing country can balance environmental protection and economic growth."[88] Acting Executive Director of UN Environment noted regarding the report's findings: "This improvement in air quality didn't happen by accident. It was the result of an enormous investment of time, resources and political will. Understanding Beijing's air pollution story is crucial for any nation, district or municipality that wishes to follow a similar path."[89] Some of the measures taken included energy infrastructure optimization, coal-fired pollution control and vehicle emission controls, with one example of progress being the 35 percent reduction in fine particulate matter pollution (PM2.5) from 2013 to 2017 as a result of measures to control coal-fired boilers.[90]

Development of new technologies was set to continue to play an important role, providing advantages ranging from less polluting methods of power generation to solar powered air purification towers. The latter was pioneered in China and proved highly effective during testing, with widespread deployment expected from the mid-2020s.[91] Improvements were particularly notable in the wake of Chinese Premier Li Keqiang's announcement in early 2014 that China would "resolutely declare war against pollution as we declared war against poverty." The *New York Times* described progress with "astounding scale and speed," reporting in 2018: "Four years after that declaration, the data is in: China is winning, at record pace. In particular, cities have cut concentrations of fine particulates in the air by 32 percent on average . . . if China sustains these reductions, recent research by my colleagues and me indicates that residents will see significant improvements to their health, extending their life spans by months or years."[92]

Regarding afforestation efforts China emerged as the world leader by a considerable margin with billions of trees planted from 1980 to 2020 under multiple programs.[93] These were concentrated in the country's less populated northern regions, with seedlings sown each year covering an area approximately the size of Belgium. Forest coverage increased from 12 percent in 1978 to 22 percent in 2019 as a direct result, with expansion expected to continue. The country also offered to export its afforestation program to neighbors such as Kazakhstan and Iran.[94] Programs grew in sophistication over time from less healthy forests using just a single type of tree to more diverse ones which could hold more carbon and release more oxygen. As the programs progressed increasingly sophisticated means of calculating the amount of carbon an area of forest was storing were developed to facilitate better decisions regarding planting in future.[95]

In parallel to afforestation efforts approximately 170 Chinese cities launched "forest city" campaigns to curb pollution, improve air quality and increase greenery in urban areas. Each city added an average of 13,000 hectares of parks or woods per year after joining. Taking the city of Xiong'an as

an example, the Millennium Forest program mixed more than 100 types of trees, with 3,600 hectares of saplings added in the autumn of 2020 alone. The plan would see 40 percent of China's urban land covered with trees and green spaces in 7 out of 10 cities by the end of the decade.[96] New cities were also being built around the 'eco-city' urban model, which featured low-energy construction materials and light mass transport as well as planned green spaces. Some reports indicated that by 2019 as many as 250 eco-cities were planned, with new models of city planning and energy efficiency making these potentially much more efficient than older settlements.[97]

Another notable field with significant potential to make China's economy much greener, which received substantial investment and where the country had emerged as a global leader by the beginning of the 2020s, was plant based and artificially grown meats. The former were increasingly aimed at meat eaters rather than their traditional vegetarian consumer base, and were proving increasingly popular as they were better able to replicate the taste, texture and appearance of animal meat.[98] The latter used animal stem cells which were harvested and nurtured to create muscle tissue, and although too costly and having yet to be approved for market it had the potential to largely replace traditional means of growing meat in future as a more efficient alternative.[99] With animal husbandry being one of the leading drivers of climate change, and requiring far more resources than its emerging alternatives, growing investments in developing better plant based and lab grown 'meats' had the potential to seriously undercut global demand for animal meat.

China's growing leadership in key emerging fields of green technologies in the form of green energy not only increased Beijing's credibility and international prestige as the issue of climate change was raised more widely, but also more importantly translated into significant economic, security and geopolitical benefits. This contrasted sharply with the United States which had neglected investment in developing many of these technologies. Speaking regarding the impact of China's tremendous leadership in renewable energies, chair of the Global Commission on the Geopolitics of Energy Transformation Olafur Grimsson observed: "The renewables revolution enhances the global leadership of China, reduces the influence of fossil fuel exporters and brings energy independence to countries around the world. The transformation of energy brings big power shifts."[100]

American efforts to control China's key maritime energy supply routes were widely seen by leading defense experts to be intended to provide leverage over Beijing[101]—much as Washington's control of oil supplies to the Japanese Empire had in 1941.[102] These efforts were seriously undermined by China's renewable energy revolution. Furthermore, leading in key green technologies and developing them to a degree that they could realistically outcompete fossil fuels by a comfortable margin in cost effectiveness before

2030 had the potential to generate significant export revenues and to bolster Chinese economic partners across the non-Western world. Influence over global oil supplies through control of the seas and hegemony over the Middle East had long been highly prized in the Western world, and had been a vital asset for the US and Britain particularly in the Second World War and the Cold War.[103] This had been expected to similarly greatly benefit the US-led Western bloc in its twenty-first-century geopolitical rivalry with China, although through concentrated investments. In researching, developing and applying a new generation of technologies China had outmaneuvered them and threatened to significantly reduce the relevance of oil and natural gas.

THE QUANTUM RACE

Emerging as a particularly fierce area of technological competition between China and the US in the late 2010s, quantum technologies and in particular in quantum computing and communications were increasingly seen to have potentially decisive impacts on the balance of power between the two countries. The importance of development in the field was stressed by President Xi Jinping in October 2020,[104] with the Ministry of Science and Technology confirming that month that quantum technology would be included in the country's Fourteenth Five-Year Plan.[105] The plan made quantum technologies a top priority for development alongside AI,[106] and investment in China's national quantum program was projected that year to reach $14.8 billion by 2022.[107] Although considered a field of undisputed US supremacy as recently as the late 2000s, China gained first place in patents in quantum technologies in 2012 and by 2018 was filing over three times as many as the US and 52 percent of all those filed in the world.[108] A 2017 congressional hearing which addressed America's falling behind in quantum technologies attributed it to "lack of funding, structural and institutional issues, and lack of government coordination" which "reduced both the levels and consistency of support that are necessary to maintain capacity in this critical research area."[109]

The Chinese global lead in this field appeared particularly significant, and in December 2020 a team of Chinese scientists claimed to have made the first definitive demonstration of quantum mechanics to perform computations that would be mathematically impossible on any classical computer—otherwise known as a 'quantum advantage.' They demonstrated the ability to perform computations in just 200 seconds which would take 2.5 billion years—over half the age of Earth—for the world's fastest existing supercomputers, and used beams of laser light to achieve this. Pan Jianwei from the University of Science and Technology of China in Hefei stated regarding the achievement: "We have shown that we can use photons, the fundamental unit of

light, to demonstrate quantum computational power well beyond the classical counterpart." He added that the calculation that they carried out—known as the boson-sampling problem—has potential practical applications in graph theory, quantum chemistry and machine learning. Physicist Ian Walmsley at Imperial College London referred to it as "certainly a tour de force experiment, and an important milestone," which reflected the consensus view among Western scientists with multiple similar statements made.[110]

Through its achievement, the team from Hefei managed to achieve what Google had failed to despite very substantial investment. Google's quantum-computing laboratory in California announced the first-ever demonstration of quantum advantage in October 2019,[111] but this was not definitive as the Hefei team's demonstration was a much simpler calculation which a regular supercomputer would be able to perform 250,000 times as fast as it would the Hefei team's problem. The Hefei team's experiment used 76 detected photons where the previous record had been just 14. A Chinese lead in the field had very significant implications, with the *Scientific American* referring to it as "a multibillion dollar enterprise recognized for its potential impact on national security, the global economy and the foundations of physics and computer science."[112] After the Hefei team set a new record for processing speed with the world's most powerful quantum computer in July 2021,[113] China's lead was subsequently widened when in October a prototype with 113 photons was detected. It was one million times faster than its closest western competitor which had been developed by Google.[114] Advances in quantum computing came as part of a broader trend toward Chinese leadership in the development of supercomputers, with figures in 2019 showing that China had continued to rapidly extend its dominance in a list of the world's fastest supercomputers with 228 (45.6 percent) of all systems listed as being installed in China. The runner up, the United States, had only 23.4 percent.[115]

Considerable Chinese advances in quantum computing continued to be made, and in January 2021 the state-run China Telecom company became the first offer sim cards to make quantum encrypted phone calls.[116] The following month the firm Origin announced development was complete for system software for quantum computers, which was made for the anticipated next generation of quantum computing hardware.[117] In July 2021 a team from the Hefei University of Science and Technology of China set a new record for processing speed with the world's most powerful quantum computer.[118] These rapid advances came as America's longstanding primacy in traditional computing was rapidly eroded—described by Northrop Grumman chief executive Kathy Warden as having "shrunk to an alarming state."[119] Chinese supercomputing firms had been sanctioned under the US trade blacklist from June 2019 in an apparent effort to stem the trend toward China's emerging primacy in the field,[120] which followed a decision under the Obama administration in

April 2015 to restrict semiconductor exports to Chinese supercomputing centers.[121] The Biden administration subsequently blacklisted seven leading Chinese entities involved in supercomputing in April 2021.[122]

Alongside its considerable civilian applications, an advantage in quantum computing had the potential to provide a tremendous edge in cyber warfare. Quantum computers were expected to be able to overcome almost any form of existing encryption and thus provide a means of penetrating and if necessary destroying enemy information networks. As a result developments in the field were made a part of China's national security strategy, with President Xi referring to it as "an advance-handed piece on the board" in reference to an advantage in the game Go which could be pivotal to scoring victory.[123] As a 2019 paper published by the School of Advanced Military Studies US Army Command and General Staff College noted regarding the sheer destructive potential that cyber attacks of the future could have if built around quantum computers: "The discussion about a large-scale quantum computer attack on a nation has grown to the same level as the nuclear deterrence discussion during the Cold War of 1945–1990. Because of the expected devastating effect of a large-scale quantum computer attack, there is a strong incentive amongst the countries that possess universal quantum computers to avoid conflict."[124] With a destructive potential comparable to a nuclear weapon such an asset could add important new levels to a country's deterrent, or even provide a means of causing serious damage to adversaries in peacetime with a deniability that kinetic weapons did not provide. Alongside their offensive applications quantum computers could also be integrated into complex weapons systems that required significant processing power—for example allowing air defense systems to more accurately autonomously fire on a target at long range while processing complex inputs from multiple sensors for guidance.

Beyond cyber warfare, the competition for quantum supremacy had other significant and wide-ranging military implications most notably advantages in the development of quantum radars and communications. The *MIT Technology Review* described China and the US as seeing: "the emerging quantum era as a once-in-a-lifetime opportunity to gain the edge over its rival in military tech," stressing that its potential impact on military communications were "game changing."[125] China was the first in the world to demonstrate quantum-secured space communication with its Micius satellite in 2020, which allowed positions over 1000km away to communicate. Micius was dedicated to quantum information science—a satellite totally unique in this regard—and produced several breakthroughs following its launch in 2016.[126] It was the latest of many Chinese technological achievements to be widely compared to the Soviet launch of the world's first satellite—another 'Sputnik moment' for the Western world showing just how far ahead the competition was as well as being another technology with significant military

implications.[127] According to the *Scientific American* the Chinese achievement: "arguably represents the nation's lead in an emerging contest among great powers at the frontiers of physics," leaving the US "scrambling to catch up." It concluded: "The achievement brings the world—or China, at least—one step closer to realizing truly unhackable global communications."[128]

As early as 2017 Micius' demonstration of quantum entanglement over unprecedented distances was seen to have placed China in a league of its own in developing quantum communications.[129] Citing Micius as an example, a 2018 paper by the Centre for a New American Security warned regarding China's rapid advances in quantum technologies:

> Chinese researchers have achieved a track record of consistent advances in basic research and in the development of quantum technologies, including quantum cryptography, communications, and computing, as well as reports of progress in quantum radar, sensing, imaging, metrology, and navigation. Their breakthroughs demonstrate the successes of a long-term research agenda that has dedicated extensive funding to this domain while actively cultivating top talent.

It highlighted that "at the highest levels, China's leaders recognize the strategic potential of quantum science and technology to enhance economic and military dimensions of national power," with one result being that scientists were "receiving nearly unlimited resources."[130] Further uses for Micius' unique communication capabilities were demonstrated in May 2021 when it was used to secure large parts of the country's power grid adjacent to the Taiwan Strait against cyberattacks or blackouts. This was seen as a show of force amid high tensions with Taipei.[131]

Reflecting the tremendous strategic advantage that superiority in quantum technologies applied to the military could translate to, widespread comparisons to being the first to field nuclear weapons have been made including from within in China's own armed forces.[132] Analysts at the Jamestown Foundation observed to this effect that quantum communications could provide an "asymmetric information advantage in a conflict scenario," while: "In future warfare, quantum computing may prove to have strategic significance on par with nuclear weapons." Quantum technologies more generally could "radically alter the rules of the game on the future battlefield" and "decisively change the future strategic balance."[133] Deputy chief of staff of the Chinese People's Liberation Army's Northern Theater Command, An Weiping, said quantum communications would drastically impact the international military balance and significantly enhance battlefield information processing facilities which would facilitate the construction of a more robust combat system.[134]

Chinese scientists had already constructed a quantum network to secure communication between government officials to coordinate a major military

parade in 2009. By early 2015, according to leading scientist in the field Pan Jianwei, China was already "completely capable of making full use of quantum communications in a local war. The direction of development in the future calls for using relay satellites to realize quantum communications and control that covers the entire army."[135] By the end of 2016 China had already operationalized and employed "unhackable" quantum cryptography to secure sensitive communications, which was made commercially available from January 2021 when the state-run China Telecom company became the first offer sim cards to make quantum encrypted phone calls.[136] By contrast, the US military had yet to even decide to invest significantly in building a quantum communications infrastructure.

Micius was followed in January 2021 by the establishment of the world's first integrated quantum communication network by China, which was a milestone no competitor was even close to reaching. Developed by the University of Science and Technology of China, the network integrated over 700 optical fibers on the ground and ground-to-satellite links to achieve quantum key distribution over a 4,600 kilometer distance. Next steps for the university's team included development of smaller and cheaper satellites, as well as satellites in much higher orbits, to expand the network's reach and capabilities.[137] This could potentially in future evolve into the beginnings of a 'quantum internet,'[138] and also had the potential to create new technologies such as 'super-telescopes' that combined light from multiple telescopes to exponentially enhance astronomical observations.[139] It also laid the foundation for the military's plans to field a network of quantum satellites that could facilitate secure communications, command and control capabilities, and the secure transmission of targeting data for long-range precision strikes. Such a network was expected to be active by 2030.[140] The quantum communication network thus had both civilian and military applications, and represented part of a wider trend of research into quantum technologies being somewhat ambiguous in its primary purpose due to its dual uses. While it was clear that quantum specialists recruited by the Chinese People's Liberation Army would be researching military applications, close ties between universities and defense firms like the China Shipbuilding Industry Corporation made it more difficult to determine which research programs had military aspects to them and, if so, how military focused they were.

Successful promotion in China of close working relationships between government research institutes, universities, and companies contrasted with the US where it took much longer to create a national plan for coordinating public and private efforts and longer still to begin to show signs of implementation. According to the *Scientific American:* "The delay in adopting such an approach has led to a lot of siloed projects and could slow the development

of useful military applications"—an issue also raised by quantum experts in the military.[141]

A further potentially decisive military application of quantum technologies beyond communications and cyber warfare was the development of quantum sensors in a range of roles to improve situational awareness. Claims of breakthroughs in developing quantum radars began to emerge in the late 2010s, most notably in Austria and in China itself with the latter unveiling a prototype in 2018. These radars worked by using twin 'entangled' photons paired with one another and sharing a single quantum state, with one of each at beamed out to a distance and one kept in the sensor itself. The process of quantum illumination would allow the far one to 'tell' the sensor a great deal about it through the changes seen in its twin. Significant progress was made by a team at Tsinghua University's aerospace engineering school in 2021, which was one of several teams working on such projects, with many experts subsequently expressing confidence in the ability of these technologies to be put to military use.[142]

Beyond radars, as surface ships in all major navies were made increasingly vulnerable even at longer ranges due to the development of assets such as hypersonic[141] [143] cruise missiles,[144] quantum sensors for anti-submarine warfare threatened to leave submarines similarly vulnerable. The importance of both strategic and tactical submarines due to their unique survivability on twenty-first century battlefields made the race to develop anti-submarine quantum sensors strategically highly significant. As observed in the *National Interest*: "China's quantum radars could make detecting US submarines a breeze"—with such sensors potentially being integrated onto satellites which could bring about "the end of underwater stealth."[145] Quantum radars also have very significant potential applications for aerial warfare. As both US and Chinese military aviation placed a growing emphasis on stealth capabilities—the ability of aircraft to evade enemy radars—a superior ability to detect and lock onto such aircraft has become potentially decisive.[146] Development of quantum radars had the potential not only to render stealth targets much less viable, if not making stealth itself eventually obsolete, but also to provide a major advantage in tracking targets such as strategic ballistic missiles and to create air defenses which are much harder to suppress and immune to anti-radiation missiles.[147] Current trajectories portend that China will have the technologies needed to field such systems long before the US can.

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PART II

The War on Huawei

Chapter 4

Huawei and the Challenge to Western Primacy

HUAWEI AND FIFTH GENERATION INTERNET TECHNOLOGIES (5G)

Founded in 1987 by Ren Zhengfei, the Huawei Technologies telecommunications company would come to play a central role China's twenty-first century rise compete at the high end of global supply chains. The company's business covered a wide range of key fields as diverse as smartphones, laptops, mobile infrastructure and microprocessors, and despite initially registering with capital of just $27,000 it quickly grew into a world leader in multiple areas of the telecoms industry. The firm initially focused on niche markets in China's remote provinces away from major cities, which were areas where more established major multinationals were not invested in competing. Only after establishing itself in these operations, which allowed it to grow considerably and move up the value chain, did it later seek to compete in major Chinese cities and then overseas.[1]

From the turn of the century Huawei quickly expanded into foreign markets with overseas sales increasing from $50 million in 1999 to $5 billion in 2005—a hundred-fold growth in just six years. By 2007, despite the rapid rate of Chinese market growth, 65 percent of Huawei's sales came from overseas markets. It had established over eighty-five overseas branches, research centers and factories and deployed wireless terminal technologies in over 100 countries.[2] This trend continued over the following decade to establish Huawei as the world's leading telecommunications firm, and by 2018 it was generating a staggering $107 billion in annual revenues from sales to clients in 170 countries and regions.[3] The company's successes, and concerted US-led efforts to target it particularly from 2018 as a means of

stifling China's economic modernization, led to a major struggle to decide whether Huawei would be allowed to continue to thrive, or forced for political reasons to fail.

In September 2015, three years before the firm gained global fame as the primary target of a renewed US campaign to broadly target Chinese high tech, the *Harvard Business Review* published an article titled: 'Huawei: A Case Study of When Profit Sharing Works.' Unlike Apple, Microsoft, Samsung or other leading competitors, Huawei was effectively run as a co-operative meaning it was "a private company owned by its employees" in which profits were shared by the company's workers. Citing an IMF study which showed that the "startlingly large" and growing inequality between CEOs and regular workers slowed down growth, damaged employee morale and productivity, and caused public relations issues, the article pointed to Huawei as a potentially highly viable model for an alternative due to its successfully implemented co-operative system.

The *Harvard Business Review* article further highlighted that Huawei's founder, Ren Zhengfei, owned only 1.4 percent of the company's total share capital, with the rest held by its 82,471 employees under an employee stock ownership plan (ESOP). It also emphasized that "the sum of employees' salaries, bonuses and dividends is 2.8 times the company's annual net profit, and plans are to further increase the ratio to 3:1." This system not only reduced inequality, but was also believed to allow the system to better create long term plans. The assessment further underlined that the Chinese tech company had its own philosophy, with its structure based on two important premises:

> The first are the Confucian values of equality and harmony, which underlie Zhengfei's desire to prevent wealth gaps between employees from becoming too big. To achieve this, Zhengfei believes that if employees own the company they will be motivated to act as entrepreneurs and initiate more projects that could help all of them to earn more and diminish differences in wealth creation considerably. This feature of providing opportunities to all employees to increase their wealth is characteristic of what an employee-owned company stands for and differs from public companies where primarily the happy few at the top are earning more by serving their external shareholders and thereby widening salary gaps within the company significantly. But although Huawei is big on creating equal access to those opportunities, they do not employ a view that also promotes equality in the distribution of outcomes.
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> The second premise is built on the idea of equity. The harder you work, the more you can earn—but working overtime is only rewarded extra if the work directly addresses the needs of their customers. Overtime projects that do not reveal direct positive consequences for customers are not rewarded. This plan not only

> controls wealth gaps and allows employees to earn more, but also allocates more influence and authority to those who show strong skills.
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> In Zhengfei's view, people care about belonging to and being proud of a collective but also have the desire to differentiate themselves from others. Huawei's ESOP can satisfy both human needs. The ESOP emphasizes the idea that Huawei belongs to everyone in the company and that Zhengfei expects all employees to act like owners, with dedication and commitment. This entrepreneurial spirit allows the company to learn and innovate, collectively, in support of Huawei's mission: 'To improve quality of life through communication.'[4]

Huawei's rapid rise to global leadership in telecommunications technologies was largely unanticipated in the West, and preceding the initiation of a tech war by Washington in 2018 which targeted the firm it was far from a household name like Apple or Samsung despite its size. Telecoms industry analyst and co-founder of the advisory firm Quadra Partners, Paul de Sa, noted regarding prevailing Western attitudes to Huawei throughout much of the period of its rise: "I do think the Western companies did underestimate how credible Huawei was. There were executives who basically laughed [at the idea] that Huawei or ZTE[5] could compete."[6]

Huawei's success was often interpreted as part of a broader trend toward Chinese firms competing at the higher end of the world economy and achieving self-sufficiency in a range of strategic technologies such as information, robotics, aerospace and biotechnology, which was seen in the US as unacceptable and an imminent threat. Research Associate at the University College London Institute for Innovation and Public Purpose Dr. Laurie Macfarlane observed regarding US efforts to target Huawei and Chinese tech more broadly: "Beneath the rhetoric about national security lies a deeper concern," namely that China could "threaten the technological supremacy that has long underpinned US hegemony thanks to its world-leading university, military and tech sectors. . . . From the beginning, the US has been concerned with preventing China's rise as a rival technological power." He stressed that as Huawei had emerged as "the unrivalled global leader in the development of 5G networks," other Chinese tech firms were expected to follow and dominate other key areas of high tech. Regarding what Huawei's rise signified as the spearhead of the Chinese tech sector's challenge to Western primacy, Macfarlane observed: "the Chinese Communist Party has developed a distinct economic model that has lifted nearly a billion people out of poverty and transformed China into one of the world's largest and most dynamic economies . . . Huawei has become the international poster child for the success of this model."[7]

By 2019, which was the year US efforts against Huawei escalated sharply, 40 percent of the world's population used telecoms that passed through Huawei equipment. The firm was dedicating over 14 percent of revenue and 45 percent of staff to research and development across fourteen international hubs,[8] and had filed for 5,405 patents the previous year alone—the largest number by any single firm in the world by a considerable margin.[9] Huawei's smartphones division took markets by storm across the world, overtaking Apple and gaining second place in sales in 2018,[10] before closing much of the gap with Samsung in 2019[11] with 240 million sales—a 16 percent increase over the previous year.[12] It subsequently took first place in the first half of 2020,[13] making it the first company other than Samsung and Apple to hold this position in nine years.[14]

The successes of Huawei's telecoms equipment and smartphones were made despite considerable politically motivated efforts by the US and its partners to undermine sales in some of the world's most lucrative markets. When Huawei was competing for a contract with US telecom operator Sprint to upgrade its mobile network in 2010, the firm came under sustained attack by figures in the American political and security establishments based on unevidenced allegations that it had special ties to the Chinese government. Huawei's US-based vice-president for external affairs at the time, Bill Plummer, stated regarding this period: "Sinophobic politicians, driven by defense and intelligence careerists, and further encouraged by Huawei competitors, launched an all-out and very public assault on the company through the Fall of 2010, drawing on the decades of misinformation that Huawei had, through its historically insular culture, allowed to fester into 'fact.'" To assuage security concerns and demonstrate transparency, Huawei offered to deliver equipment via a third party firm that would conduct an independent audit of the hardware, firmware and software before delivering it to Sprint. The firm also hired the Cohen Group business advisory firm, founded by former US Defense Secretary William Cohen, to negotiate a framework through which Huawei could provide its equipment. These efforts ultimately failed, however, and allegations persisted that Huawei was part of a Chinese government conspiracy to infiltrate the US.[15]

In 2018, following the surge in popularity of Huawei smartphones worldwide,[16] the firm had planned to begin widely selling them in the United States primarily through partnerships with carriers AT&T and Verizon. Following high sales globally of its popular Mate 10 phone, and ahead of the launch of its highly anticipated new P 20, both carriers withdrew from plans to work with the Chinese firm without explanation in January. These moves were widely interpreted as a response to US government pressure, with several analysts citing sources which reportedly confirmed this and some interpreting it a sign that US and Chinese markets could become more polarized due

to such political intervention.[17] With over 90 percent of Americans buying smartphones through carriers, the inability to work with any carrier in the US undermined potentially lucrative sales, with Huawei's phones having gained a very substantial market share wherever they were permitted to compete.[18] The following month in February, the directors of the CIA, FBI, NSA and several other US intelligence agencies commended moves by carriers to keep Huawei smartphones out of American markets. Beyond this, they urged Americans not to purchase Huawei phones.[19]

America's largest electronics retailer Best Buy, which was expected to supply a large proportion of Huawei products, reported in March that it would remove all of them from its website. This was described by analysts as a "just the latest blow to Huawei's US ambitions" and "devastating for Huawei," and was also widely seen to be a result of US government pressure.[20] The availability of Huawei phones, tablets and laptops continued to decline in the US over the next two years as a result of government action, with the Microsoft Store and Walmart stopping all sales of Huawei devices in early 2019 and Adorama, a smaller seller, delisting them from searches in its online store.[21] Beyond the US, its close strategic partners Britain and Japan followed suit with major carriers such as EE, NTT Docomo, KDDI and SoftBank delaying or pausing the release of new Huawei phones, suspending preorders for new models, or cancelling plans to do business with the Chinese firm entirely.[22] Aside from these three countries, however, Huawei's global smartphone sales profile remained strong.

Despite the global successes of its smartphone sales, concerning as they were for Western interests, it was Huawei's achievements in another field, that of fifth general broadband cellular networks (5G), which was the primary factor leading the US and its partners to take a hard line against the company. Each generation of mobile technology enabled a new suite of innovations, from mobile voice communications that emerged with the introduction of 2G to ride-sharing services like Uber which were facilitated by 4G. The shift from 3G to 4G had represented a drastic change in how people could use the internet, for example allowing for the downloading, uploading and livestreaming of high-resolution videos at will where previously even small music files often strained connectivity. This had given rise to multiple new innovations capitalizing on what mobile data had become capable of. The 5G revolution promised to be considerably more transformative still,[23] and would usher in an entire ecosystem of services and products the nature of which was difficult to predict even for experts. Better driverless cars, the ability to perform manual jobs virtually from another location, and new live virtual reality services, were among the many possibilities raised. Some analysts went so far as to compare 5G to the introduction of electricity: "a critical enabler that could bring about new applications and opportunities that we can't yet

imagine."[24] The new generation of internet technologies was predicted to contribute $13.2 trillion to the global economy, and to generate 22.3 million jobs from direct network investments and residual services.[25]

By 2020 Huawei was employing 96,000 people for research and development alone—a tremendous 49 percent of its total workforce—and had invested $4 billion in the past decade on 5G R&D. This was more than the total invested by all its Western competitors combined.[26] By the mid-2010s it had emerged with a clear global lead, and by the end of the decade one in every five 5G proposals vetted by the international standards-setting organization was from Huawei reflecting it considerable lead over all competition.[27] By the end of 2020 the firm had more than 3,000 patent applications and had installed over 690,000 5G stations in China alone.[28] Patents were vital for a firm to turn major innovations into royalties and were a strong indication of successful innovation, with Huawei's primacy reflecting an overall trend toward Chinese innovation primacy in 5G. By March 2019 approximately 34 percent of the world's major 5G patent applications came from China, compared to 25 percent from South Korea and 14 percent from the United States. China's share of 5G patents was notably around 50 percent higher than its 4G share, reflecting a broader trend toward the country's growing dominance in the telecommunications field and in high tech more generally.[29] As the *Wall Street Journal* noted in November 2020: "China is no longer just leading the US when it comes to 5G. It is running away with the game."[30]

A prominent example of Huawei's key role in 5G was its pioneering of 'polar coding,' which used algorithms to correct for errors and thus allowed for a far faster transmission of data. Polar coding was adopted at a 2016 industry conference to set standards for the fifth generation of wireless infrastructure, which affirmed Huawei's place as a leading standards setter with a central role in 5G development. As *Bloomberg* noted regarding the implications: "those who define the standards are the ones most intimately familiar with the technology at the core of the next wave of commercial deployments . . . while others are still trying to figure out the blueprint of next-generation infrastructure, Huawei will already be building it."[31]

5G was a rapidly growing market projected to reach approximately $33 billion in value by 2025,[32] and its significant strategic implications due to its knock on effects for other areas of high tech meant that Chinese primacy in the field was perceived in the West as both shocking and unacceptable. As CEO of the Rivada Networks communications technology firm Declan Ganley observed: "The stakes are high, they encompass everything from commerce to defense. 5G will be one of the deep 'blue oceans' of the 'cyber' domain, which is now just as important as land, sea, air or space. It's hard to overstate how important the war for 5G is."[33] According to *Time,* competition in 5G represented "the most consequential fight for global technological

supremacy" since the space race in the Cold War. "The winner will take home billions, if not trillions, in profits and gain a powerful seat at the table in creating the infrastructure for the next billion Internet users. And right now, it looks like the US is losing."[34] It highlighted regarding the arrival of 5G in the United States on April 3, 2019:

> [It] would have been a banner day for American IT infrastructure, were it not for the fact that citizens of Hangzhou, Shanghai and Wuhan had all been enjoying experimental 5G networks for months. In Fangshan, autonomous vehicles are already using 5G to transmit data to one another to avoid collisions. China's edge in 5G is disorienting for the US, which is used to dominating new technology and the economic growth that accompanies it. If the US lags in 5G, does it lose the opportunity to birth the next Amazon, the next Netflix, the next Uber?[35] . . . 5G means a lot more than just another bar on your cell phone. The hop from 3G to 4G meant we went from being able to read an article on our phones to being able to stream a movie. But the leap from 4G to 5G will mean an exponential rise in download and upload speeds across every Internet-connected device you own, the ability to connect those devices to a single network easily and the ability to off-load computing to the cloud. It's not only the most significant shift in computing since the smartphone, it will also enable huge advances in industries like automated vehicles.[36]

As highlighted in a paper by the Hudson Institute think tank the following year, when compared to foreign competitors such as China, South Korea or even European countries: "by any objective measure, the US telecom industry is well behind."[37] Indeed, villages in rural China would receive 5G before major cities such as Boston and Philadelphia.[38] A Brookings Institute report in April 2020 described government and private sector efforts to roll out 5G in the US as both being "slowed by the local and federal bureaucracies, restrictive and outdated regulations, and scarcity of available commercial spectrum." The shunning of hardware from Huawei and ZTE, which were both "integral to the global supply chain for 5G equipment and software," only further exacerbated the American disadvantage.[39]

A notable sign of the nature of America's position was that when Apple released the new iPhone 12 in October 2020 the 5G speeds it provided were far too fast for US networks to take advantage of, but were ideal for consumers in China and South Korea. Associate director of research firm Strategy Analytics, Boris Metodiev, compared using an iPhone 12 in America to driving a Ferrari "in your local village," where the roads just couldn't handle its high performance. This applied to several high end handsets which residents of the US would for the foreseeable future not be able to use in ways their counterparts in countries which were ahead in 5G infrastructure could.[40] The solution proposed, and the title of Hudson paper itself, was simple:

"attack Huawei's value chain."[41] As noted by the head of geotechnology at the Eurasia Group political risk consultancy company Paul Triolo, the US government had "no credible strategy" to rapidly deploy 5G.[42] The result was a very considerable lead for China and South Korea in particular, the latter which had worked closely with Huawei.[43]

By early 2018 signs of Western concerns regarding the emerging Chinese lead in 5G had become more conspicuous. In January a leaked National Security Council document showed prevailing concerns in Washington with the success of Chinese firms in developing 5G, stating that "China has achieved a dominant position in the manufacture and operation of network infrastructure." This led the White House to even consider proposals for nationalizing the country's 5G network, which could have potentially better allowed it to keep up with private sector Chinese competition. Such steps were proposed as early as 2017 in a National Security Council memo which was later leaked, and emphasized that without that kind of extensive government intervention there was a real risk that the gap in competitiveness between Chinese and Western telecoms equipment would only grow further.[44] This would have represented an unprecedented nationalization of infrastructure which had historically been private, but was advocated on the basis of its lower cost and the fact that it could be achieved faster than allocating the task to the private sector. Government sources reported that the nationalization option was favorable because "a single centralized network is what's required to protect America against China and other bad actors," despite the possible market disruption this could cause.[45]

While Washington did no go as far as nationalization, an increase in government intervention was evident and aimed both to target Huawei and to strengthen US and Western telecoms firms. An example was the move in March 2018 to block the Singapore-based semiconductor producer Broadcom from acquiring its US competitor Qualcomm under the pretext that this would undermine the latter's ability to tackle Chinese competition.[46] CEO of the Rivada Networks communications technology Declan Ganley highlighted that month that possible nationalization was widely opposed by the private sector, which enjoyed dominance under the existing system. This opposition was considered to be one of factors which led to proposals for nationalization ultimately floundering. Ganley stated to this effect regarding the influence commercial interests of telecoms firms had:

> Right now, China has the edge in 5G. Why? Because Europe and the US inherited a 'top down' model of all-encompassing wireless conglomerates that have become a rent seeking spectrum oligopoly. 'Top down' is what China does best and what the West does worst. It's not too late for the US or even Europe to flip the script and win the 5G game in the equivalent of injury time.[47] That's going

> to take something big, like the 500 MHz wholesale 5G plan that has been discussed in the US National Security Council or an equivalent move by Europe or even the U.K . . . The West's problem is our powerful wireless incumbents' commercial interests are currently aligned with the Chinese model and so they will resist a game changing move.[48]

Analysts at *CNBC* concluded that Europe was also lagging behind in the race to lay down 5G infrastructure, highlighting: "Fragmentation in rules across the European Union's 28 member states, a lack of investment from mobile networks stemming from weak business, and continuing debate over the allocation of radio waves known as spectrum, are the key reasons for the region falling behind." With China predicted to have by far the largest market for 5G, this was expected to give Huawei and ZTE considerable advantages, with its "top-down approach . . . helping to boost the efforts of local carriers to roll out 5G."[49] As chief of research at the mobile and wireless market information, analysis and intelligence firm CCS Insight, Ben Wood, highlighted: "Europe is significantly lagging China and North America when it comes to 5G commitments and deployment. In the US, we've got intense competitive rivalry between the leading players which is accelerating investment in 5G, and in China there is absolutely no question that they see an opportunity to innovate their own 5G, which would be the first generation of technology where they could really be the undisputed leader."[50]

A year later signs of a major Chinese advantage in 5G spearheaded by Huawei in particular had grown far clearer. In May 2019 an assessment by *Time* joined the ranks of others in concluding that Huawei had "all but cornered the market for 5G technology."[51] By that time its global market share stood at 29 percent—almost equivalent to the combined share of its two closest rivals with Finland's Nokia and Sweden's Ericsson which accounted for just 17 and 13 percent respectively.[52] The three firms between them were the only ones building the most crucial infrastructure of 5G networks and providing vital back-end equipment for transmitting data among the core network and user equipment, which meant Huawei effectively had only two competitors in the field. Cited by the *Washington Post* the chief executive at the network intelligence and analytics company Sagent, Gordon Smith, estimated that Huawei equipment typically cost "tens of percents" less than the competition's. The *Post* noted: "Huawei today is recognized for low prices, reliable equipment and engaging customer service, analysts say. As Huawei has invested in its own research and development, even Western telecom companies acknowledge that Huawei's products are as good as—if not better than—competing equipment from Nokia or Ericsson." It was among the many sources to highlight that the company's efficiency benefited greatly from economies of scale, as its operations were so much larger than those

of any competitors which in turn gave it an edge with cheaper products and more funds available for research and development.[53] Giving an indication of its price competitiveness, in April 2019 officials from the Netherlands' leading telecommunications carrier KPN cited a 60 percent price advantage when choosing Huawei as well as a qualitative edge.[54]

By 2020 Huawei's global market share for service provider equipment was greater than Ericsson and Nokia combined.[55] The two northern European firms were widely seen as "financially shaky,"[56] with debt bonds emerging from junk bond status only in 2017 and only to lowest-grade investment status in 2018 and 2019. Both companies suffered negative net income in most quarters since the beginning of 2017,[57] with Nokia suffering a significant stock market downturn after announcing that it would not meet its original growth targets for 2020 and would not be paying dividends.[58] Huawei's dominance was pronounced not only in 5G, but also in the preceding generation. By 2016 it was already supplying more than half of 4G mobile networks globally and 66 percent of global '4.5G' networks.[59]

If left to compete freely for contracts without politically motivated interference, Huawei was set to establish itself in the large majority of countries as the leading provider of 5G equipment by a very considerable margin. Thus to preserve its own position of primacy, the US and a number of its strategic partners initiated a dual track campaign in 2018 to neutralize the world's leading telecommunications firm and thereby restore some form of Western dominance. A report by *France24* would describe Washington's new hard line stance as a "zero-sum approach," with a presidency that was "obsessed with China's hardware, deplores the absence of a fully American vertical monopoly and declares 5G a 'race' that China must lose for America to win."[60] The first track of the campaign centered on efforts to deny Huawei access to parts of the global supply chain which were still under Western control—namely semiconductor chips which although primarily produced in East Asia relied on foreign inputs and particularly on American software for their fabrication. The second track involved a political campaign to demonize Huawei and to pressure countries across the world to shun business with the firm. This was pursued through strongly ideological rhetoric and relied heavy on the issuing of threats against non-compliant countries which sought to work with Huawei. Through such efforts, a global conflict would emerge where states were torn between the superior contracts Huawei could offer, with technology which was both far more sophisticated and cheaper than its competitors, and American coercion including both rewards for shunning the firm and penalties for cooperating with it. Beyond threats, US-led efforts to press countries to arbitrarily ban Huawei consistently relied on appeals to ideological solidarity and portrayals of a Chinese security threat.

STOPPING HUAWEI: ESPIONAGE AND WESTERN SURVEILLANCE BACKDOORS

Although the US campaign to undermine Huawei became highly conspicuous as a leading foreign policy priority under the Donald Trump administration from 2018, the Chinese telecoms firm had been targeted extensively by American intelligence agencies from the first year of the Barack Obama administration. Information provided by whistleblower Edward Snowden from the US National Security Agency (NSA) revealed some of the extent to which Huawei was being targeted, with operations conducted with the involvement of the White House intelligence coordinator and the FBI. The White House's involvement notably began shortly after the inauguration of a new administration in January 2009 which had made containing and undermining China a foreign policy priority as exemplified by its Pivot to Asia Initiative. Leaked documents revealed that in their operations against Huawei, the NSA reported they had "good access and so much data that we don't know what to do with it." Although the American agency carried out its operations under the pretext that Huawei could provide the Chinese government with a signals intelligence capability, the documents released showed a very conspicuous lack of evidence to support this assertion or any close ties between the company and China's security services.

US government hackers succeeded in infiltrating the servers of Huawei's central office in Shenzhen in 2009 and straddled the company's communications. Huawei was at the time seen as a threat to US and Western interests primarily because the network infrastructure business has been dominated by Western firms—firms which the rise of Chinese competition was making "less relevant." With technology standards long having been shaped by American and to a lesser extent by European companies, and with an increasing amount of the flow of information on the internet coming through China, the intervention of American intelligence agencies was seen as vital to perpetuating US and Western dominance.[61]

Germany's *Der Spiegel*, which alongside the *New York Times* was given access to the NSA documents leaked by Edward Snowden, reported that Chinese President Hu Jintao, the Chinese Trade Ministry, Chinese banks and telecommunications companies were all among the agency's targets. "But the NSA made a special effort to target Huawei," it emphasized. The German paper reported regarding the findings on NSA activities against the Chinese telecoms giant:

> At the beginning of 2009, the NSA began an extensive operation, referred to internally as 'Shotgiant,' against the company, which is considered a major competitor to US-based Cisco. The company produces smartphones and tablets,

> but also mobile phone infrastructure, WLAN routers and fiber optic cable—the kind of technology that is decisive in the NSA's battle for data supremacy. A special unit with the US intelligence agency succeeded in infiltrating Huawei's network and copied a list of 1,400 customers as well as internal documents providing training to engineers on the use of Huawei products, among other things. According to a top secret NSA presentation, NSA workers not only succeeded in accessing the email archive, but also the secret source code of individual Huawei products. Software source code is the holy grail of computer companies. Because Huawei directed all mail traffic from its employees through a central office in Shenzhen, where the NSA had infiltrated the network, the Americans were able to read a large share of the emails sent by company workers beginning in January 2009, including messages from company CEO Ren Zhengfei and Chairwoman Sun Yafang.[62]

With access to Huawei's source code, the NSA wanted to add backdoors to allow it to spy on all parties including the several countries which used the firm's equipment.[63] Huawei spokesman Bill Plummer slammed the NSA's actions, stating: "If it is true, the irony is that exactly what they are doing to us is what they have always charged that the Chinese are doing through us . . . If such espionage has been truly conducted, then it is known that the company is independent and has no unusual ties to any government and that knowledge should be relayed publicly to put an end to an era of mis- and disinformation."[64] As the *New York Times* reported: "the National Security Agency was creating its own backdoors—directly into Huawei's networks. The agency pried its way into servers in Huawei's sealed headquarters in Shenzhen, China's industrial heart . . . it obtained information about the workings of giant routers and complex digital switches that Huawei boasts connect a third of the world's population." Beyond a search for ties between Huawei and the Chinese military, which the NSA failed to find, the goal of the operation was

> to exploit Huawei's technology so that when the company sold equipment to other countries—including both allies and nations that avoid buying American products—the NSA could roam through their computer and telephone networks and conduct surveillance and, if ordered by the president, offensive cyberoperations.

The *Times* also highlighted that the US was conducting its own industrial espionage for the benefit of the American economy.[65]

In 2012 the US House of Representatives Intelligence Committee warned against American telecommunications operators using Huawei equipment, with the White House subsequently ordering a review of the security risks posed by it and other Chinese telecoms suppliers. The 18-month review concluded that, in stark contrast to the prevailing portrayals of Huawei in

the West, there was no evidence that the firm was installing back doors in its equipment for espionage purposes.[66] One of the government employees involved in the inquiry into Huawei told *Reuters*: "We knew certain parts of government really wanted evidence of active spying. We would have found it if it were there."[67] While there was little evidence to support Western claims that Chinese telecoms companies were implicated in espionage activities or working for the country's intelligence agencies, evidence of US malpractices more severe than anything ever even alleged against Huawei were very substantial. It was the NSA, not a Chinese government agency, which sought to install backdoors into Huawei equipment for espionage purposes, and Western intelligence agencies similarly installed secret backdoors in Western chips and other hardware to aid its surveillance efforts in collaboration with tech giants across the Western world.[68]

US and Western efforts to undermine Huawei were overwhelmingly premised on the pretext that infrastructure put in place by the Chinese telecoms giant could be used for espionage, but the total lack of evidence despite intrusive penetrations into the firm's networks with the express purpose of finding it seriously undermined this narrative. Aside from undermining China's efforts to compete at the high end of the world economy, for which Huawei did play an important role, a key motivation for the campaign against the telecoms giant was that its global usage undermined America's offensive options to project military force overseas. Former Senior Director for Cyber Operations on the US National Security Council Staff, Thomas Donahue, stated to this effect in a 2020 paper published by the National Defense University Press that while "most discussion of the Huawei issue centers around 'espionage,'" this was not a major concern as "encryption and authentication technology can be used to protect confidentiality and integrity of communications."

Donahue did warn, however, that if Huawei equipment was widely installed across the world it could potentially deny US forces the ability to conduct "the full scope of information-based warfare strategies" overseas. This was important because:

> As a global power, the United States must be able to sustain military forces and project power anywhere in the world, even in the face of resistance from a sophisticated adversary with the ability to infiltrate or disrupt telecommunications and other critical infrastructure within the United States, in space, under the ocean, and in other regions of the world . . . ensuring trusted communications infrastructure on a global basis for the United States or the proper functioning of other foreign critical infrastructure depended on by the US military and other US interests overseas.

Huawei's potential threat was thus not to America's defense, but rather to the country's ability to use networks overseas for projection of military force. Washington's issue with Huawei's equipment being widely used outside the United States was that it could potentially be closed off in wartime as an asset for the US military to conduct operations on other continents.[69] Donahue was hardly the only one to highlight this, with Professor Clive Williams from the Australian National University's Centre for Military and Security Law noting to similar effect that while there was a lack of evidence for Huawei conducting espionage or having a special relationship with the Chinese government, it would be expected "in an extreme adversarial or conflict situation" to follow Beijing's commands. This meant it would likely deny the US military the ability to use its networks in wartime—although Williams stressed that this was hardly out of the ordinary with American firms expected to do exactly the same thing in such a situation.[70]

A prominent paper published by the Council on Foreign Relations in 2019 similarly asserted that the US needed a global 5G network which would allow it to relay commands to its forces and project its military power across the globe. It stressed that any country's decisions regarding next generation of commercial civilian telecommunications needed to be shaped by requirements for resilient global command and control of US military assets and other US defense interests. The paper stated to this effect that there were

> tactical and operational implications on the battlefield of conducting conventional or counterinsurgency operations in an area with Chinese owned or operated 5G infrastructure . . . Chinese telecom infrastructure dominance in a theatre of operations may limit the US military's ability to conduct precision targeting that leverages signals intelligence collection on 5G telecommunications networks . . . the US military needs to anticipate that its use of native telecommunications infrastructure in a future operating environment may be compromised, limited, or denied.

Ensuring that global 5G networks were laid down by Western or Western-aligned parties was thus seen as imperative because having these in place was vital to America's ability to wage war abroad.[71] A notable example of how control of telecommunications infrastructure could influence the balance of power in a theatre of operations was provided by the Russian-Ukrainian War in 2022, where the American Starlink satellite internet constellation provided key support to Ukrainian precision strikes and intelligence collection while this was denied to Russian forces.[72]

Where the US military enjoyed exclusive access to many valuable mid-band frequencies domestically, Huawei was notably selling equipment which exploited those frequencies—giving clients a better performance

but also making it somewhat more difficult for American forces to operate. While the impact of this was often exaggerated, with encrypted communications being much less affected, it was still cited as a further reason why the US should oppose proliferation of Huawei's equipment. The US military preferred to reserve many of the optimum frequencies globally for its own overseas operations and discourage any country from using them for civilian purposes.[73] A notable example of how control of telecommunications infrastructure could influence the balance of power in a theatre of operations was provided by the Russian-Ukrainian War in 2022, where the American Starlink satellite internet constellation provided key support to Ukrainian precision strikes and intelligence collection while this was denied to Russian forces.[74]

Donahue's influential paper stressed that it was necessary for "the United States to define how other countries choose to implement infrastructure that US national security communications may need to pass through."[75] This did raise questions about the extent to which America expected the world to effectively bend over backwards to ensure that the US could still project military force globally. It also raised the question as to what the Western response hypothetically would have been to a Chinese paper claiming the entire world had to shun Ericsson and Nokia to ensure that the Chinese military retained its ability to project power offensively across the globe. Requiring the entire world to make such serious policy changes by shunning the most advanced and cost effective 5G provider—simply to accommodate America's perceived need to project military force overseas—certainly hardly seemed reasonable to most. As a result, Huawei was portrayed by Washington as problematic not because it undermined American offensive options, but on the much less well evidenced premise that it undermined the host country's defense.[76]

Beyond its possible limitations on American power projection capabilities, Huawei did indeed pose a very real threat to Western interests by rapidly gaining market share and setting industry standards in a field previously dominated by the West, as well as by undermining the US and its allies' ability to spy on the world. As Singapore's former foreign minister George Yeo stated in an interview in March 2019: "using Huawei also makes it harder for American intelligence to gain access into other people's systems . . . If you have a Huawei system it is harder for the Americans to do all this. So we can understand why they are not happy with Huawei."[77] As several Westerners working in government jobs in data forensics informed the writer, Huawei phones and tablets were extremely difficult to access whereas it was easy for Western intelligence agencies to get data from a Samsung or an iPhone. Huawei's moves to introduce its own operating system, and to set up infrastructure across the world using components which were not produced in Western or Western-aligned states, would only further seriously undermine the Western powers' ability to conduct global surveillance. Such surveillance

was vital to Western interests considering that Western militaries retained presences in the large majority of countries in the world,[78] meaning the US and its allies perceived a very real need to be able to spy on the world more freely than Huawei networks would allow.

STOPPING HUAWEI: CREATING A WESTERN RIVAL

America's inability to compete with China in 5G had a number of causes, including what was widely characterized as an oligopoly in the US telecoms industry resulting in a lack of effective market competition.[79] With the Telecommunications Act of 1996 having removed checks against market consolidation, leading to mergers and acquisitions which reduced competition, development was increasingly impaired.[80] The 2001 American telecoms crash which devastated the industry,[81] and the lack of significant government support in its aftermath, only furthered this trend.[82] According to a 2018 assessment by Thomas Donahue: "The major telecommunications integration capabilities at the switching and physical layers in North America over the past two decades largely disappeared in bankruptcy or were absorbed into foreign firms as the North American firms failed to keep up with new technologies or compensate for Internet-driven commoditization and declining prices . . . the United States now finds itself in a similar place as China was twenty years ago"—meaning with a telecoms sector far behind its strategic competitors.[83]

A 2020 paper by the National Defense University Press observed regarding the contraction of the American telecoms sector that after the 2001 crash Washington "had made 'free market' decisions by allowing US industry to succumb to global market forces" which left America "without the usual means to compete, namely its own industry" when facing challenges from Huawei and ZTE.[84] An example of a direct consequence was the takeover of former American market leader Lucent by France's Alcatel SA and subsequent absorption into Finland's Nokia.[85] Lucent itself had previously acquired the Octel Communications Corporation, Ascend Communications and Livingston Enterprises Inc.

Adjunct senior fellow with the technology and national security program at the Centre for a New American Security, Elsa Kania, observed in February 2020 that Chinese leadership in 5G was driven by "a more synergistic vision of how the state and private enterprises work together." She contrasted this strongly with the ineffectiveness of US policy since the mid-1990s which had facilitated the emergence of an effective oligopoly in American telecoms, stating regarding its consequences: "Today, Americans visiting cities like Seoul or Shanghai are often shocked by how fast and cheap their

mobile connections are, far better than what's available at home. That's the consumer-facing side of the imbalance that also exists on the back end of the network."[86] Citing the telecoms industry, the *New Yorker* in 2013 observed regarding the detrimental impacts of America's telecoms oligopoly on competition that this was largely facilitated by the US government. It stated to this effect that "the United States has nowadays nearly abandoned scrutiny of oligopoly behavior, leaving consumers undefended."[87]

The Barack Obama administration had notably considered subsidizing an American firm to go back into the telecoms networking business as a 'national networking champion,' and went so far as to consider using the Defense Production Act to do so. This idea was abandoned after it emerged it would be outspent by its Chinese rivals by at least 100:1. Talks on reviving the US telecoms networking sector made it as far as a Deputies Committee meeting, but none of America's major information technology companies were willing to re-enter the field. As noted by the director of the Strategic Technologies Program at the Centre for Strategic and International Studies, Vice President James Andrew Lewis: "the administration ultimately decided to rely on Google and Silicon Valley to innovate our way out of the problem without the need for the government to spend anything. This was around the time that Google purchased Motorola Mobility, now owned by Lenovo, a Chinese company, and appeared to be toying with the idea of going into telecom. Google changed course for business reasons, leaving the United States back where it had started."[88]

Calls for the US to intervene to support a Western competitor to Huawei came from across much of the Western world. Former Canadian Prime Minister Stephen Harper, for one, stated to this effect in early 2020: "Ultimately, the government of the United States is going to have to work with allies to make sure that there are Western providers of all these equipment and services. Otherwise, the pull toward Huawei will get stronger and stronger."[89]

Huawei's continued rise spurred renewed efforts beginning under the Donald Trump administration to address shortcomings in the US telecommunications industry through government intervention. These did not address the major underlying issues in the industry, but instead focused on strengthening American firms with funding and with acquisitions of European technologies. The need for new legislation was consistently premised on the need to counter Huawei specifically. One of the first was a report on 'Defense Applications of 5G Network Technology' by the US Defense Science Board in June 2019, which recommended that the Department of Defense "should provide seed funding for western industrial base alternatives of key system components" to compensate for shortcomings in the existing industrial base.[90]

On January 14, 2020, new legislation introduced to the US Senate by Republican Senator Marco Rubio and five fellow senators aimed to create a Western competitor to Huawei in 5G. The Utilizing Strategic Allied Telecommunications Act stipulated "providing over $1 billion to invest in Western-based alternatives to Chinese equipment providers Huawei and ZTE," and was intended to "reassert US and Western[91] leadership."[92] Senator Rubio highlighted that efforts to press foreign countries to ban Huawei were being seriously undermined by the lack of any close competition from the Western world in terms of either sophistication or price. Referring to Huawei as a "malign state-directed telecommunications companies that pose a clear and growing threat to the economic and national security of the US and our allies," the senator warned that the world was "at a critical point in history for defining the future of the US-China relationship in the twenty-first century"—for which it was vital to ensure American supremacy in 5G.[93]

The bill called for the creation of a $500 million fund in partnership with foreign allies to speed up adoption of "trusted and secure equipment globally," as well as the creation of a blueprint to wean small and rural American telecoms companies—many of which were particularly highly reliant on Huawei equipment[94]—to shift to non-Chinese equipment. It also stipulated that the US should seek to create and dominate the standards that govern the next generation of telecommunications technologies, and to prevent China from using its lead in 5G to do the same at international standard-setting bodies. Western suppliers would also be encouraged to expand and adopt common standards to drive down the costs and bridge the vast affordability gap with Huawei.

Co-sponsor of the Utilizing Strategic Allied Telecommunications Act, Senator Mark Warner, highlighted that the bill was vital to improve the market share of "US and Western companies" in 5G. He warned that without action, Huawei was "poised to become the cheapest, fastest, most ubiquitous global provider of 5G."[95] The bill was introduced just a day after State Secretary Mike Pompeo, addressing the Silicon Valley Leadership Group, stated that China "presents unique challenges, especially to your industry." Pompeo emphasized the importance of pressing for Huawei to be banned by American partners across the world, which was a goal the new bill would support.[96]

While the bill ultimately passed the house in November 2020, the funds allocated were very small particularly considering both the low purchasing power the dollar had in the US relative to China, and the far greater investments being made abroad. Huawei invested $15.3 billion on research and development in 2018 alone,[97] while Finland's Nokia spent $5.46 billion, and Sweden's Ericsson spent $4.48 billion. Huawei's lead only grew in subsequent years, with R&D spending increasing from approximately $13–15 billion per

year in 2017–18 to $15–20 billion per year from 2019–20.[98] Although it sent a strong political message, a $1 billion American spending package was hardly going to be a game changer—referred to by some analysts as "small change" relative to the sums being spent by the private sector.[99] As highlighted by James Andrew Lewis at CSIS, the United States' unwillingness to invest more money in winning the technological competition was its biggest disadvantage when competing with China. Taking semiconductors, which played a central role in 5G networks, as an example, he stated: "China might outspend us a 1,000-to-1 when it comes to investing in semiconductors and a 1,000-to-1 is no way to win the race."[100]

On February 27, 2020, the US approved a $1 billion bill to subsidize efforts by rural telecom providers to replace Huawei and ZTE equipment. The legislation had been proposed in September on the basis that Huawei had achieved widespread coverage in rural America, and that many small providers would not be able to remove or replace it without totally removing phone and 4G service from many areas of the country.[101] The fact that Huawei had more viable near-peer competitors in 4G than it did in 5G meant that replacing older generations of equipment was much simpler. Nevertheless, a later report by the US Federal Communications Commission (FCC) in September showed that $1 billion would be far from sufficient to cover the costs of replacing Huawei equipment in rural areas due to how widely it was used, with the figure estimated at approximately $1.8 billion. According to the report, dozens of telecoms companies in the US were using Chinese equipment from Huawei or ZTE, including some 50 small companies as well as larger ones such as Verizon and CenturyLink.[102] Former Senior Director for Cyber Operations on the US National Security Council Staff, Thomas Donahue, was one of many to highlight that "small rural carriers would face existential financial hardships transitioning away from Huawei," with the transition the US government had imposed for political reasons having serious negative economic consequences.[103] The FCC nevertheless went on to order the removal of equipment made by Huawei in December.[104]

Also in February Attorney General William Barr said he was positively inclined toward the idea of US acquisitions of European telecommunications firms Nokia and Ericsson to compete against Huawei. "Putting our large market and financial muscle behind one or both of these firms would make it a more formidable competitor and eliminate concerns over its staying power," he stated.[105] National Economic Council Director Lawrence Kudlow similarly highlighted: "Nokia, Samsung and Ericsson, they're still very much in the game and they're adding to their presence in the US . . . We want them to move here and we might help them out. We might pay some moving expenses, but that's different than actual ownership."[106] Although Samsung sought to build on its expertise in semiconductor manufacturing and its strong

brand name from its smartphone and semiconductor businesses to gain a market share in telecommunications infrastructure, this was a relatively new field for the South Korean firm. It had only a very small market share at the time and could not be considered an alternative to Huawei, Nokia or Ericsson. The fact that Samsung did not supply basic 2G or 3G equipment, which operators needed even as they built their 5G networks, was a serious shortcoming. Indeed, Samsung was widely rumored from 2014–2018 to be considering exiting the networking business altogether.[107] Huawei remained the only firm that could provide end-to-end 5G systems all the way from smartphone chips to wireless base station antenna to network routers and switches.

A report from the *Wall Street Journal* in June 2020 noted that Trump administration officials were considering "inserting the federal government deep into the private sector" as part of a "broad federal intervention to secure 5G future," in an attempt escalate competition against Huawei. The possibility of such a move was "discussed intermittently with US tech giants, private-equity firms and veteran telecom executives." US government efforts to create a Western competitor included unsuccessful attempts to persuade networking firms like Cisco or Oracle to consider trying to compete at a similar level, and to persuade Cisco to buy one of Huawei's rivals like Ericsson or Nokia which would narrow the Chinese firm's prevailing lead. Providing tax breaks to Nokia or Ericsson was also considered. "The ideas show how far the US is willing to go in its fight with China over who will supply the world with advanced technologies," the *Journal* noted.[108]

The proposed government intervention to create a US-European competitor to Huawei followed a 5G summit meeting planned by the White House in early April with Nokia, Ericsson, Dell, Intel and Microsoft, as well as Samsung, to coordinate a plan to best counter the Chinese telecoms giant, although this was cancelled due to the COVID-19 crisis.[109] Moves by the White House in this direction notably followed the publication of a paper in 2019 by telecoms experts including former head of the National Aeronautics and Space Administration, Daniel Goldin, and former Nokia technology executive, Hossein Moiin, which advocated in the strongest terms cooperation within the Western world to ensure Western leadership in 5G. Emphasizing the need for urgent action, it stated regarding 5G: "For the first time in modern history, the United States has not been the leader in an emerging wave of critical technology." The paper strongly influenced thought on the matter at the White House, with many pushing for the US to work with other Western firms and either investing in Nokia and Ericsson or buying control of one or both companies.[110]

Tech analysts at PhoneArena noted regarding these developments surrounding Huawei: "The company, as the US has already discovered and the U.K. is now discovering, has a technology lead over its rivals which makes

it hard to replace . . . While there are US firms in the business, they are too small to compete with the major players in the industry."[111] As Nokia's policy chief for the Americas Brian Hendricks observed regarding the lack of an industrial base in the United States for such technologies: "the US has been out of the game for a while."[112]

While it was unlikely that acquiring European telecommunications companies that were themselves already being comfortably outcompeted by Huawei would enable the Western world to gain parity with Chinese or even Korean 5G technologies, coordinating R&D efforts could provide a better chance of competing in future generations. Washington's ability to exercise unfair competition and threaten countries with penalties (see chapter six) if they dealt with Huawei meant a potential Western competitor did not necessarily need to outperform or even match its Chinese rival. It only needed to compete in something approaching the same league, after which political coercion of potential clients could more easily compensate for Western equipment's shortcomings in terms of performance and cost effectiveness.

There was a growing consensus among analysts, particularly from 2020 as momentum for government action gradually faded and the Western world faced a new economic crisis, that the US government could not create a viable competitor to Huawei in 5G. A particularly harsh criticism of US efforts was published in June 2020 by *New Eastern Outlook*, a paper managed by the Russian Academy of Science's Institute for Oriental Studies, which observed:

> The US appears to have done everything in its power to fight Huawei besides actually competing against it. Competition would involve the creation of technology similar or superior to Huawei's either in terms of performance or cost, or both. The US is unable to do this . . . The fact that the US' most recently announced the perhaps most drastic measures so far against Huawei involve 'investments,' 'equity firms' 'acquisitions' and 'holding companies' rather than improving education in relevant fields, domestic manufacturing and technical expertise, reflects a fundamental inability for the US to compete against China on equal terms. As long as the US insists on facing its growing problems by moving numbers around on financial ledgers rather than picking and placing components on circuit boards inside the US, it may temporarily delay Huawei's rise but in no way stop it.[113]

The erosion of America's technological and industrial bases (see chapter eight) had left it in a very poor position to compete. As the *New York Times* observed just three days later, the government "has done little to build up other companies that could compete with Huawei and other Chinese technology leaders," which led it to try to compensate by focusing on attacking Huawei.[114]

The limited options available for viable US or Western competition to Huawei, and their less than promising prospects in the eyes of many analysts, led to louder calls for aggressive action against the Chinese telecoms giant to undermine it and thus provide Western firms with more of an opportunity to catch up. In a prominent article by the *Hudson Institute* in September 2020 Senior Fellow & Director at the Centre for Defense Concepts and Technology, Bryan Clark, and Adjunct Fellow at the center, Dan Patt, stated to this effect: "US alternatives to Huawei are unlikely to mature before the company solidifies a dominant position in 5G. Instead, the US government needs to mount a more proactive approach using its ongoing efforts in the Department of Defense to attack Huawei up and down the 5G value chain." They called for attacks to on the Chinese firm's value chain to be paired with investment in an American rival, stating: "US leaders hope export controls on semiconductors made or designed with US technology will check Huawei's progress or a global competitor to Huawei will emerge before the company restores its supply chains. Neither outcome is likely. The Trump Administration's trade restrictions create a window during which it should mount a coherent high-low strategy that creates viable US competitors before Huawei can recover." Regarding Huawei's advantages, they highlighted that it was "making the largest contributions to 5G technical standards" and "receiving more 5G patents than any other company"—a growing advantage seen as unacceptable by proponents of US and Western supremacy.[115]

Reflecting the sense of urgency to develop a Western competitor to Huawei, the US Central Intelligence Agency (CIA) was reported in March 2020 to be funding 5G developers which had the potential to challenge Huawei. The CIA had for decades conducted operations in the interest of American and Western global hegemony which went well beyond intelligence collection and espionage—the kind of operations governments and militaries could not directly do themselves. In the past these had ranged from assembling, arming, training and directing private mercenary armies for offensive operations,[116] to bombing a Chinese embassy,[117] to establishing and operating secret overseas military bases with support from funds from narcotics trafficking activities.[118] The agency's move to fund competitors to Huawei was part of a longstanding trend of it moving faster and more quietly than Capitol Hill to do what was seen as necessary to sustain US and Western hegemony. In the Cold War it had been military operations without the checks and balances of using the US military, and in the tech war on China it was funneling funds to any Western firm which looked like it could potentially challenge Huawei in 5G.

CIA efforts to counter Huawei's primacy in 5G had begun long before 2020. It had contracted a venture capital fund named In-Q-Tel to invest in 5G startups, and a major recipient of CIA money through this fund was a US based telecommunications service provider named Parallel Wireless. The

firm was developing technologies using a software-centered approach specifically with countering Huawei in mind. Its co-founder, chairman and CEO, Steve Papa, stated to this effect: "Parallel Wireless is committed to destroying the threat Huawei poses to the free world . . . We are actively working to ensure America and the world are free from the constraints of Huawei. Parallel works with many companies, many governments and many government agencies including In-Q-Tel."[119] While the full details of CIA involvement in the tech war against Huawei will likely never be known, the known extent of the agency's involvement in supporting Western competitors was a strong indicator as to the extent to which Huawei was viewed as a threat to Western supremacy and the Western world's geopolitical interests.

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Chapter 5

America's Campaign against Huawei's Value Chain

HUAWEI ON AMERICA'S 'ENTITY LIST'

On May 15, 2019, President Donald Trump signed two executive orders targeting Huawei. The first banned American firms from using equipment or services from firms that Washington deemed to be under the control of "adversary governments," which was drafted primarily with Huawei in mind despite the lack of evidence of ties to the Chinese state. The second ordered the Commerce Department to place Huawei and 68 affiliates on its Entity List, which required American firms to request a special license to do business with it. To remain in compliance with the listing Google LLC blocked Huawei products from accessing parts of its Android operating system while US semiconductor producers, which between them had sold approximately $10 billion worth of components to Huawei in the preceding twelve months alone, were obliged to follow suit. Cybersecurity fellow at the New America think tank Samm Sacks, who regularly briefed the US Congress on China policy, stressed that the Entity List was always considered the "nuclear option." "This is not just crippling on Huawei as a firm, but crippling on the entire concept of global tech supply chains," he said, with countries which relied on its technologies for their communications infrastructure also potentially being affected.[1] Huawei maintained long afterwards, however, that there would be no disruptions in its telecoms infrastructure business, which used semiconductors much larger and easier to source and fabricate than those found in smartphones and of which it also retained a significant inventory.[2]

Android was used by all major smartphone manufacturers other than Apple, which relied on its own IOS, and by imposing severe restrictions on both Huawei's access to Android and its access to Google applications the US

government appeared to be seeking to push the firm out of global smartphone markets. Android OS and IOS had an effective duopoly over 99.9 percent of the global smartphone operating system market, and without an alternative Huawei's smartphone business would struggle to continue. Under the blacklist, Google was also forced to stop providing technical support and collaboration for Android and Google services to Huawei. The restrictions were later loosened slightly to allow Google Play, which Android users relied on to download apps, and the security features of the Google Play Protect antivirus software, to continue on existing Huawei devices. Despite this, new versions of its smartphones would still lose access to popular applications and services such as Google Maps and Gmail. The Commerce Department announced a ninety-day exemption on May 20, but by then Huawei had already escalated efforts to cut its areas of dependence on Western technologies which were few in number but still difficult to overcome. Doing so required the firm to be able to secure semiconductor supply chains and to develop an alternative operating system.

Although Huawei's high end flagship smartphones released in 2018 and early 2019 such as the Mate 20 Pro and P 30 Pro had seen strong sales performances overseas and achieved deep penetration of many Western markets, software restrictions imposed by the US were repeatedly cited as the key reason why their successors such as the Mate 30 Pro, P 40 Pro and Mate 40 Pro achieved negligible penetration.[3] With Google's software and applications having gained very considerable brand loyalty, Huawei was placed at a steep disadvantage overseas where its high-end smartphones had otherwise been poised for market dominance prior to the new round of restrictions.

The demonstrated potential of Huawei's very unique business model, and the phenomenal increases in overall sales it was continuing to see despite wide ranging American efforts to hinder it, fueled predictions that the firm would in the long term be able to secure a position at the high end of global smartphone markets. As founder Ren Zhengfei stated in 2019 shortly after the restrictions on Google and Android software were imposed, when asked whether Huawei could still become the world's number one smartphone brand without Google's support: "I don't think that would be a problem, but it just takes time. When I say it takes time, what I'm referring to is the overseas market, because we will return to the overseas market next year, and the year after that."[4] Huawei would within months be declared the world's leading smartphone manufacturer, although to maintain its lead it would ideally need to develop an indigenous ecosystem for applications similar to those created by Apple and Google. Once that was achieved, undermining Huawei's ability to penetrate global markets for high end smartphones would become much more difficult.

A key step toward eliminating reliance on American inputs was the development of the indigenous operating system HongMeng OS (known outside China as 'Harmony OS'). Like Apple, this would allow the firm to sell devices such as smartphones, speakers and tablets without reliance on software from Google. Hongmeng was a well-kept secret until it was announced in 2018, but had been under development for six years before then as a strategic investment in case of a sudden American attack—precisely the kind of attack the Trump administration had initiated.[5] Huawei's founder Ren Zhengfei stated to this effect: "We are developing our own OS out of strategic consideration because won't we be doomed if they suddenly cut off our food, don't allow us to use Android or Windows 8."[6]

HongMeng was reported in June 2019 to be 60 percent faster than Android, although replacing all features offered by Google would take many more years.[7] With Chinese local media speculating that all Chinese phone brands could be made compatible with HongMeng, this had the potential to provide the new operating system with the backing needed to gain a very substantial market share globally. This could be facilitated by the very high popularity of Chinese smartphone models, which enjoyed the majority share in many of the world's largest countries' markets.[8] Several analysts indicated that the chances of other Chinese tech companies working with Huawei to support an independent domestic operating system, particularly as the US moved to more broadly target China's tech sector, was high.[9] Hongmeng OS was declared ready by the CEO of Huawei's consumer division Richard Yu on August 9, 2019, and would be able to replace Google software "immediately" should the US adopt harsher restrictions.[10] This revelation during a period of escalating conflict could have been intended to deter to such action by the US.

Hongmeng was launched in early 2020 and went on to be integrated onto smart cars, with technology analysts speculating early in 2021 that the operating system could pose the "biggest threat yet" to Google's Android as the possibility grew that it could be more widely used on handsets beyond Huawei's own.[11] With Apple's IOS being a key attraction that was long seen to give its phones a major market advantage over other smartphone brands relying on Android,[12] Hongmeng notably more closely resembled IOS than Android with a similar 'smoothness' and ease of use. The system was received very positively internationally, with the executive editor of the Macworld tech site, Michael Simon, referring to it as "the iOS-iPadOS mashup we want Apple to make" and a "solid reimagining of Apple's iPadOS." It "very much feels like IOS but more integrated and elevated," he observed, highlighting that it was made very easy to move features and controls between different Huawei devices. "Huawei didn't just copy IOS and iPad OS—it also made it better in all the right ways," he noted, expressing hopes that Apple could catch up when it next updated its own operating system. Simon's assessment

was echoed by several analysts in the aftermath of Hongmeng's release.[13] Hongmeng thus had the potential to make Huawei phones considerably more popular, and certainly more user friendly, than they had been when using Google's Android system.

Speculation that Hongmeng would replace Android on multiple non-Huawei phone brands was further fueled by a leak on Chinese social media in early May 2021 to this effect.[14] Indeed, the very existence of the new operating system served as an effective deterrent to potential future US government efforts to target other Chinese smartphone manufacturers as it had Huawei, as with a replacement for Android already ready doing so would only strengthen Huawei and Hongmeng and undermine Google. Huawei notably intended to offer applications from Google in Hongmeng's own app store, which could allow its operating system and its phones to appeal to a wider range of clients that were unwilling to part with Google services. This would hardly be unprecedented, with Apple's app store offering Google application for users of its own self developed operating system.[15] Hongmeng quickly went on to receive a major update in June, Hongmeng OS 2.0, which gained 25 million users within a month and 70 million in less than three months despite not yet being available for older Huawei devices. Rising to 120 million users in September, it built a strong foundation for further development as a peer level competitor to Android and IOS.[16]

BLOWBACK FROM RESTRICTIONS OF HUAWEI—SUPPLY CHAINS WITHOUT WESTERN INPUTS

In the long term, moves against Huawei would only increase China's and Huawei's technological self-reliance by providing a key impetus to cutting inputs from the West and the US in particular out of supply chains due to their unreliable political tendencies.[17] The result for American firms was a serious loss of revenues and of market share. Editor in chief of China's *Global Times* state media outlet, Hu Xijin, tweeted to this effect on May 21, 2019, regarding Washington's move to place Huawei on the Entity List: "The US cutting off Huawei supplies completely woke up Chinese society. China will face difficulties in short term. We will devote to independent R&D and abandon any illusion. But it is also a real turning point of the US semiconductor companies gradually losing Chinese market."[18]

Huawei's placement on the Entity List in May 2019 allowed it to effectively demonstrate how easily American components could be replaced. A major loophole in this new measure—the fact that suppliers could keep on selling to Huawei as long as the components were made outside the United States—only strengthened the trend toward an undermining of American

manufacturing. As the world's largest smartphone manufacturer, Huawei's demand was a major boon for Taiwanese chip suppliers and a major loss to their American rivals. As the US and wider Western world had long since lost their monopolies on the world's cutting edge of high-tech manufacturing, Washington's leverage was much more limited than many had expected. A prominent article in Japan's *Nikkei* thus referred to Huawei's response as "mobilizing Asian suppliers for a production surge" and "leading a split from US technology"—one which had been forced on it by Washington's actions.[19]

By December 2019, and by some estimates much earlier, Huawei was producing top of the line phones without any US sourced components, with the small portion of parts they had represented proving to be easily replaceable.[20] As semiconductor analyst at the Susquehanna International Group, Christopher Rolland, stated regarding the signal this sent: "When Huawei came out with this high-end phone—and this is its flagship [Mate 30 Pro]—with no US content, that made a pretty big statement."[21] Thus although the US eased some restrictions on American firms supplying parts Huawei in late November,[22] by that time their market share had already been largely lost. As the *Wall Street Journal* observed, US government policies meant that it was "too late" for American firms to resume supplying the world's largest telecoms company with parts.[23] The cost in the US of a possible complete cut in semiconductor trade with China was expected to cost $80–100 billion in sales and 125,000 American jobs.[24]

American firms suffered substantial losses, with exports of chips to Chinese firms making up a significant and fast-growing part of global demand. Qorvo, an American maker of radio frequency products, said sales to Huawei and its affiliates had accounted for $469 million in the fiscal year that ended on March 30, 2019—15 percent of its total revenue. It was forced to lower its revenue outlook for the year, citing Washington's actions targeting Huawei as the cause. Lumentum, another major American supplier to Huawei, reported that sales to the Chinese firm had accounted for 18 percent of total revenue in the first quarter of 2019 before restrictions by the US government were imposed. It was also forced to revise its revenue guidance negatively for the subsequent quarter as a result.[25]

In January 2020 the US Commerce Department considered tightening controls on American firms' exports to Huawei by imposing a threshold for American content in offshore sales to the firm at 10 percent, down from the previous 25 percent, meaning it would affect a much wider range of products.[26] This was interpreted by some analysts as a response to the limited effects of previous measures, after Huawei had boosted 5G technology sales by a full 20 percent that year despite strict export restrictions and a concerted campaign to pressure countries across the world not to buy.[27] Considering the size of Huawei, however, the new restrictions carried the

risk of further sidelining American manufacturers. The Defense Department notably blocked planned restrictions, with its decision reportedly receiving the full support of the Treasury Department. The reason for this, according to Defense Secretary Mark Esper, was that the fallout from such controls could not only cause serious disruption to supply chains of the affected companies, but would also have negative implications for American innovation. The benefit of harming Huawei was exceeded by the toll doing so would take on American firms. As the *Wall Street Journal* noted: "the Pentagon is concerned that if US companies can't continue to ship to Huawei, they will lose a key source of revenue—depriving them of money for research and development needed to maintain a technological edge."[28]

The *Asia Times* went so far as to infer that this "appears to be an admission of defeat in the US-Chinese tech war, which in the long term is far more important than the trade war." The *Times* further cited a conciliatory statement by US Treasury Secretary Steven Mnuchin in London on January 25 that Washington might not oppose Huawei's participation in some parts of Britain's 5G network, despite the administration having previously drawn a hard line on the issue. Regarding the fragility of the American position, the *Times* concluded:

> US technology companies, especially chip designers, sell the great majority of their products in Asia. China's chip design and manufacturing capacity is expanding rapidly with a blank check from Beijing, and US companies fear that Huawei and other Chinese companies will retaliate against US export controls with a price war for the high-end chips that power smartphones and servers. The Pentagon and Treasury objections to the proposed export controls indicate that the balance of power in the global chip industry has shifted toward China.[29]

Failure to realize the fragility of its position had only further served to sideline an important part of the relatively little high tech civilian manufacturing the United States had left. China's tech firms, meanwhile, moved to accelerate the strengthening of their chip sector and hired 3000 Taiwanese chip engineers to build fabrication facilities on the mainland.[30] While Huawei didn't manufacture its own semiconductors at the time, instead designing them and commissioning other firms such as the Taiwan Semiconductor Manufacturing Company (TSMC) to fabricate them, a shift to relying on suppliers from the Chinese mainland, or even to fabricate chips itself, was a significant possibility in the medium-long term. Imported expertise from Taiwan provided a valuable means of facilitating this transition, which would not only most likely be cheaper but would also effectively end American leverage by creating conditions for much greater self-reliance in China's telecommunications

sector. Options for further eroding Huawei through attacks on its supply chains appeared to be becoming increasingly limited.

THE 'NUCLEAR OPTION' FOR ATTACKS ON HUAWEI'S VALUE CHAIN

By the beginning of 2020 measures against Huawei were increasingly seen to be having underwhelming results, with even the firm's most vulnerable major sector, its smartphones, seeing a 16 percent increase in sales in 2019 and rising to first place in global markets in the first half of 2020.[31] This led the US to consider more radical means of undermining Huawei, with *Reuters* reporting in March 2020 that senior Trump administration officials had drawn up new plans which again focused on targeting the firm's access to semiconductor chips. As the world's largest contract maker and a major producer of chips for Huawei, TSMC was reportedly the primary target of the new offensive.[32] Imported cutting edge semiconductors were required for Huawei to produce handsets such as smartphones and tablets, while larger more widely available chips were used in base stations for telecoms infrastructure. These two types of products made up an estimated 90 percent of the firm's business.[33]

Huawei's chairman Eric Xu issued an unusually harsh rebuke of the reported plans for escalated attacks, stating that the firm would find alternative means of acquiring chips if the measures were passed. "The Chinese government would not sit there and watch Huawei being slaughtered. I believe there would be countermeasures," he stated. Xu further warned that "if China takes countermeasures, the disruptive ripple effects on industries across the globe would be enormous. Once Pandora's box is opened, it would have devastating chain effect on global ecosystem. Huawei would not be the only one to be destroyed." He also cautioned that that American companies would be harmed by the fallout of such escalation should it be pursued. "Even if Huawei cannot make chips anymore, I believe many other Chinese companies will come to the market and make home-grown chips," he stated.[34]

On May 15 the Trump administration went through with plans to escalate the targeting of Huawei's semiconductor supply, which the Commerce Department described an effort to "strategically target Huawei's acquisition of semiconductors that are the direct product of certain US software and technology."[35] Washington banned any company worldwide from using software tools made by US firms, such Cadence and Synopsys, or manufactured using equipment from American suppliers, such as Applied Materials or LAM Research, from supplying custom built chips to Huawei using them. Although the US role in the semiconductor industry was limited, its software inputs had no comparable substitutes. It was on this basis that Deputy Secretary-General

of the Chinese Academy of Sciences, Dr. Tan Tieniu, had warned China's most senior leadership at the thirteenth National People's Congress Standing Committee eighteen months prior in November 2018: "the market for chips is controlled by Americans. And suddenly if they stop selling—what that means, you understand. And that's why China, Japan, and any country, you need core technologies."[36]

The May 2020 restrictions were seen as a major blow not only to Huawei, but also to its chip suppliers such as TSMC and South Korea's SK Hynix for which Huawei remained a very major client as the world's largest smartphone producer.[37] The new restrictions hit Huawei's lucrative and fast-growing smartphone business particularly hard, as the fabrication process for the smallest and most sophisticated chip designs used in modern phones had no alternatives to those produced in Taiwan and South Korea with American software. The Commerce Department allowed chips already in production to be delivered within 120 days without the producer suffering penalties from Washington, which was interpreted as an effort to soften the short-term blow to manufacturers, although their positions in the medium term were still highly compromised. The announcement of the rule followed the announcement earlier in the week of an extension of a May 2019 executive order barring US companies from using telecommunications equipment made by Huawei or ZTE.[38]

On August 8, it was announced that production of Huawei's flagship Kirin 9000 chipsets, which powered its most advanced handsets, would cease the following month due to American restrictions on suppliers. The Kirin was the world's first 5 nanometer smartphone chip with an integrated 5G modem and was widely considered the most advanced and capable in the world. Although the chip was designed by Huawei's HiSilicon and produced by TSMC, it relied on software from American firms to fabricate.[39] With TSMC able to manufacture only a portion of the ordered chips before the ban on using American inputs for Huawei orders came into force on September 15, this would reduce the number of new Mate 40 smartphones Huawei could put out into the market. Chinese firms had the capability without US software to produce chips to 40nm or above, a relatively large size which had begun to be used approximately fifteen years prior, although these still accounted for the bulk of the total global demand for chips. An independent capability to produce smaller more advanced chips with precision, which was needed for high end smartphones, would at a very conservative estimate take over three years to develop.[40]

On August 17, 2020, the Trump administration implemented further measures in its 'War on Huawei,' as it had increasingly come to be widely referred, building on measures passed in May with moves to further limit the company access to semiconductors. The administration added thirty-eight Huawei

affiliates to the US government's economic blacklist, which raised the total to 152 blacklisted affiliates since Huawei was first listed fifteen months prior.[41] The US would also prevent Huawei from obtaining 'off the shelf' semiconductor designs without a special license to prevent the firm from acquiring chips through third party intermediaries,[42] with licenses being required even if Huawei was not the end customer and only played an intermediate role in the supply chain. Since previous sanctions had allowed Huawei to acquire chips made with US software so long as they were not designed by the firm or its subsidiaries, blocking its access to 'off the shelf' chips represented a serious escalation which some analysts referred to as a likely "death blow" to telecoms giant.[43] The *Financial Times* described restrictions as "watertight" due to how widely American software was used to fabricate chips for high end smartphones and to the fact that any and all chips going to Huawei were now targeted.[44]

While American firms built a very small number of chips compared to those in Taiwan, South Korea and the Chinese mainland itself, American software and equipment was used almost universally by manufacturers. Although moves to restrict Huawei's access to American chips had failed to sufficiently harm the Chinese firm, the new rounds of attacks leveraged the widespread use of US software to expand restrictions to chips made by foreign firms and provided a much wider reach. Several Western media outlets such as *Forbes*[45] and the *Financial Times*[46] claimed this would herald the end of Huawei's smartphone business, as advanced smartphone chips produced without using US-origin software were not available. *Bloomberg* referred to it as "the nuclear option on Huawei," comparing it to "launching a nuclear warhead aimed directly at Huawei"—the very worst the US could do short of physically bombing the firm's headquarters and killing its workers. It indicated, however, that firms in Taiwan in particular which had supplied Huawei would also lose significant revenues,[47] with stocks of Huawei's Taiwanese and Hong Kong suppliers diving in the aftermath.[48]

The *Financial Times* notably referred to the latest American actions as "the climax of a fifteen-year battle against Huawei that began when the company tried to enter the US market for the first time in the early 2000s." It highlighted that the American goal had for years been to "kill Huawei," for which the US government had now expended every possible major option, but warned that the tech giant could expect considerable state support to weather the new round of attacks.[49]

While the 'nuclear option' would prove disruptive for Huawei in the short term, in the long term it risked pressing more suppliers, such as those in Taiwan, to look to alternatives to phase out American inputs. Considering the size of Huawei's supply chain and the importance of the firm to multiple major suppliers, it was likely from the outset that many would consider such

a course. With the only alternative being to abandon the world's largest telecoms equipment provider and smartphone manufacturer, the US had provided firms internationally with a strong incentive to develop a fabrication process for advanced semiconductors as quickly as possible which had no need for American inputs. Reliance on US technologies, which played a crucial but still small role in the supply chain, had now become major liabilities to firms such as TSMC due to Washington's political interventions. The prize for the first parties to develop such an 'American free' fabrication capability for high end chips would be nothing less than the ability to supply the world's largest and by far the fastest growing telecoms giant.[50] The possibility that the US would impose further restrictions to target other Chinese firms in future, further eroding the client bases of semiconductor producers, only strengthened the incentive.

As tensions surrounding chip supplies rose three new Chinese startups were established between March and September 2020 either by or employing executives and designers from Cadence and Synopsys, the two world leaders in the field, to develop software for semiconductor production. These included include X-EPIC, Hejian Industrial Software, and Advanced Manufacturing EDA Co. As veteran engineers and high-level executives left the leading US chip design toolmakers for opportunities in China, access to this knowhow was expected to significantly accelerate the difficult process of phasing out American software from the production process.[51] As a *Financial Times* source from a Chinese chip developer reported: "We are seeing more and more people who previously worked with big US chip design tool companies joining startups because they think it's a once-in-a-lifetime opportunity. Previously very few people would want to start up a chip design tool company because it's a very niche market already dominated by huge players, but now they see growing customer demands for local software in China for the very first time."[52]

David P. Goldman, a prominent American economist who had served in senior positions at Bank of America, Cantor Fitzgerald, Asteri Capital and SG Capital among others, gave a more extreme assessment in early September in an article titled: "Huawei sanctions will destroy US chip industry."[53] Considering the prevalent trends in the industry, and the impact of prior rounds of US sanctions, he may not have been far off the mark. With new restrictions on the uses of American technologies targeting a company which was so globalized and massive, and the high possibility of Washington similarly targeting others in future, it was guaranteed that firms would seek with some urgency to end reliance on these technologies.

As noted by *Foreign Affairs* in June 2020, as part of a general trend toward American contributions to tech supply chains being much more replicable than Chinese ones: "Blocking Huawei's access to US technology,

for instance, may just encourage foreign companies to redesign their supply chains around non-US technologies."[54] Even for those supplying other Chinese firms, the possibility that similar new American restrictions would perhaps next target Oppo, Xiaomi, or any other, strongly incentivised chip manufacturers worldwide to phase out American inputs. It was China which had the world's largest telecoms company and the majority of its top smartphone brands,[55] and America which was providing some limited inputs for the supply chain. By trying placing extreme conditions on the use of its limited inputs into supply chains at the expense of Huawei's suppliers, Washington may have failed to realize the weakness of its position. After this climax of the American offensive campaign passed, options for further eroding Huawei beyond further political pressure on countries across the world to ban its hardware were extremely limited.

Reuters reported that by June 2020 the tech war had already "turbo charged" Chinese state investment in semiconductor development.[56] The National Integrated Circuit Industry Investment Fund allocating 204 billion yuan (approximately $30 billion) for chip projects in 2019, following a previous allocation of 139 billion yuan ($20 billion) in 2014. Tens of billions more came from private investors. As co-founder of chip maker Nuvolta, Huang Jin-biao, observed: "It's not just the government, it's the private sector too—everyone in China is trying to invest in something related to semiconductors." Partner at New Vision Capital Kay Li referred to "money is gushing into this sector," which was the general consensus regarding private investment in China' semiconductor industry.[57]

China's semiconductor industry was among the sectors given highest priority for accelerated development under the Fourteenth Five-Year Plan ratified in October 2020,[58] with the goal of domestically producing 70 percent of the semiconductors used by Chinese industry by 2025. This was a highly ambitious goal for a very short five year period.[59] While by 2019 Chinese industry used 60 percent of all semiconductors produced worldwide, only 30 percent were sourced domestically with imports totaling over $300 billion.[60] Spending on chip imports in the 2010s exceeded that on combined imports of crude oil, iron ore and primary plastics.[61] Reflecting these aims, Chinese investment in semiconductor development increased by 467 percent in one year from around 30 billion yuan in 2019 to 140 billion yuan in 2020.[62] A very high proportion of imported chips could be substituted with domestic ones without the need for Chinese producers to be able to fabricate the smallest most complex products. Even TSMC which produced the world's most sophisticated semiconductors gained nearly 17 percent of its revenues in the final quarter of 2018 from eight-year-old 28nm designs, and a further 37 percent from even older processes, for a total of 54 percent.[63] Mainland firms were by this time more than capable of producing 14nm chips, and by 2021

were on the cusp of producing the country's first 7nm chips,[64] which made a 70 percent goal far more attainable in the near term than the goal of fabricating the latest 5nm chips.[65] The initial rate of industry growth raised the possibility that the 70 percent target could be exceeded by 2025 and ensure self-sufficiency in all but the most cutting edge chip designs. From May 2020 to May 2021 alone semiconductor output increased by 37.6 percent, with the rate of growth only expected to rise in the following years,[66] while the number of newly registered chip-related companies in China more than tripled in the first five months of the year compared to the same period in 2020.[67] The *Asia Times*, among others, highlighted these successes as signs of a "US chip wall starting to crumble."[68] In 2021 the growth in semiconductor output was double that of 2020 at a staggering 33 percent.[69] Beijing aimed to have the domestic component market reach $237 billion by 2023.[70]

Domestic firms invested heavily in improving not only the sophistication of their chips, but also the quantities they could produce. A prominent example was the investment by China's largest semiconductor manufacturer, the Semiconductor Manufacturing International Corporation (SMIC),[71] of over $9 billion in a plant in Shanghai and $7.6 billion in a plant in Beijing. The former was China's first production line built to manufacture fin field-effect transistor (FinFET) semiconductors, which capitalized on new technologies for a denser and more efficient design. These programs were strongly supported by Beijing, with the government-backed China Integrated Circuit Industry Investment Fund and the Shanghai Integrated Circuit Industry Investment Fund respectively owning 37.6 percent and 23.8 percent stakes in the Shanghai venture.[72] SMIC had previously focused primarily on production of larger semiconductors with applications other than smartphones, but the circumstances of the tech war had presented an excellent opportunity to expand into higher end, smaller and more advanced chips.[73]

SMIC's starting point as the 'chip war' escalated in 2020 was far behind the world leader TSMC, and while the Taiwanese firm could fit 171.3 million transistors into every square millimeter of its 5nm chips, SMIC's best products were 14nm in size and fit only around 35 million transistors into a square millimeter.[74] These were still sufficient, however, to power mid-range handsets such as the Honor Play 4T, but a major weakness SMIC suffered, as did TSMC, was the continued reliance on foreign inputs.[75] Besides expanding the scale and improving the sophistication of the domestic chip industry, eliminating foreign inputs from the fabrication process, most notably American software and Dutch lithography machines, would be another greater challenge. The latter were responsible for imprinting circuits on photosensitized silicon wafers using light beams to produce semiconductor chips, with advanced miniaturized chips needing shorter-wave light in the extreme ultraviolet spectrum range to fit more transistors onto each piece of silicon. The size of

the market for semiconductors, however, meant returns on investment from being the first to develop viable substitutes was very considerable.[76] The US responded to SMIC's initial moves toward establishing a more independent fabrication capability for more advanced chips by imposing restrictions on exports to the firm in September 2020 which would obstruct its purchases of manufacturing equipment and raw materials.[77] Washington had in 2019 also placed pressure on the Netherlands-based firm ASML, which had an 80–85 percent share in the world market for all semiconductor lithography systems (the other 15–20 percent held by Japan's Nikon and Canon) and a 100 percent monopoly on advanced extreme ultraviolet (EUV) lithography equipment, to block sales of both and particularly the latter to China. Completing development only in 2018, EUV equipment was vital to set up fabrication lines for cutting edge 5nm chips.[78]

Although a contract with ASML was signed in March 2021 to supply SMIC these would be deep ultraviolet rather than EUV lithography machines. They were unable to support the fabrication of cutting-edge chips under 10nm and could thus avoid US sanctions. The bulk of chips ASML's machines would facilitate production of would be 28nm nodes used primarily in automobiles and aerospace, where EUV machines sold to TSMC and Samsung were facilitating 5nm production.[79] Allowing this sale offset some of the fallout that restrictions on business with Chinese firms would have for ASML, although as the fastest growing semiconductor producer the inability to supply China freely was still a serious hindrance to the firm.[80]

Other foreign firms seeking contracts to support Chinese semiconductor manufacturing also faced significant American pressure, a notable example being South Korea's SK Hynix which saw plans to refurbish Chinese chip-making facilities for more efficient production derailed in late 2021 due to U.S intervention.[81] Despite US restrictions analysts generally remained optimistic regarding the prospects of SMIC and China's chip industry in general particularly in the medium-long term. An important factor in this optimism was that TSMC's technologies were seen to be nearing their limits as precision approached the thickness of a single atom and improved at a much slower rate.[82] SMIC's substantial revenue and profit increases in 2021, and its relatively stable share price that year, were other factors. A promising sign came in April 2021 when, after twenty years in development, the chip firm Loongson Technology completed its first fully self-developed central processing unit (CPU) architecture with an original instruction set. This breakthrough promised to make it much easier for Chinese firms to independently design semiconductors in future.[83] SMIC was subsequently reported in October to have made breakthroughs in developing a fully indigenous 7nm chip, which could soon begin manufacturing, although the product it developed was still considered 35 percent inferior to those of the industry

leaders TSMC and Samsung.[84] SMIC's R&D efforts were not pursued in isolation, but rather as part of a broad and fast growing ecosystem of Chinese firms working to modernize the semiconductor industry which made multiple breakthroughs between them.[85]

Considerable research was undertaken by Chinese institutes to develop ultra-high precision laser lithography machines with some breakthroughs, although with the technological gap between ASML and the rest of the world being so large it was expected to take until at least the late 2020s to achieve parity.[86] ASML's EUV lithography machine was referred to by some industry experts as "probably the most complex tool humankind ever developed since it stopped jumping between trees,"[87] with senior vice president at IBM Dario Gil calling it "definitely the most complicated machine humans have built."[88] Having cost over $10 billion and taken twenty years of research to develop, requiring inputs from Germany, Japan and the US, and facing over a decade of delays due to its complexity, replicating this capability represented perhaps the hardest obstacle in Chinese efforts to gain full self-sufficiency in semiconductors.[89] Referred to by *Fortune* as "a strategic necessity for the world's industrial superpowers,"[90] calls in the West[91] to keep these machines out of the hands of countries with non-Westernized political systems, and steps to deny them to China,[92] made it imperative to accelerate the development of an equivalent fabrication capability outside Western control.

Reports emerged in 2021 of efforts in China to avoid the need for lithography machines altogether by leapfrogging existing chip fabrication technologies and focusing on the development of photonic chips, with the University of Science and Technology of China and the Nanjing University of Science and Technology being leading developers. This emerging technology had the potential to produce higher quality semiconductors than even ASML's EUV machine, and thereby to eliminate the need for any Western inputs in the fabrication process.[93] This outcome was predicted by ASML CEO Wen Peter, who warned in April 2021: "If you shut out the Chinese with export control measures, you'll force them to strive toward tech sovereignty, in their case real tech sovereignty . . . In fifteen years' time they'll be able to do it all by themselves—and their market [for European suppliers] will be gone."[94] The US Semiconductor Industry Association and Boston Consulting Group were among the many sources that similarly warned that policy was encouraging China to break ASML's monopoly and gain greater self-reliance.[95] Senior vice president at CSIS James Lewis highlighted the precedent of self-reliance in the Chinese space program to similarly predict that blocking access to semiconductor technologies would eventually strengthen the Chinese position relative to America.[96] Amid growing reports by 2022 of breakthroughs by Chinese firms analysts generally remained optimistic regarding China's position.[97]

As early as 2017 experts at *Semiconductor Intelligence* among other sites and journals were predicting that China would become the world's largest semiconductor producer in the 2020s, with the country having accounted for over 50 percent of the global market in the period of 2013–2017 and this figure only having further increased by 2020. Analysts highlighted a number of factors, including an explosion in China's Integrated Circuits industry from an already sizable $21 billion in 2010 to $65 billion in 2016. Purchases of semiconductor fabrication equipment in the country grew 180 percent from $2.3 billion in 2006 to $6.5 billion in 2016. This Chinese boom in semiconductors notably coincided with a Western and Japanese decline, with North America and Europe having both seen a fall in purchases of 39 percent during this period while purchases by Japan fell by 50 percent. The runners up to mainland China in terms of percentile growth—South Korea and Taiwan—had during this period grown 10 percent and 67 percent respectively.[98] This trend led China to emerge as the largest market for fabrication equipment by 2020, which represented a very significant increase. Where in 2017 Chinese industry made just 3.8 percent of global semiconductor sales at $13 billion, by 2020 it had reached 9 percent of the world market at $39.8 with a 30.6 percent growth rate.[99]

Even before the tech war with the US, the rate of growth of Chinese semiconductor fabrication capabilities was attributed largely to government initiatives to bridge the gap between the massive demand of the world's largest electronics industry, that in China, and the country's much more modest ability to fabricate chips. Means for government stimulation of the industry ranged from very significant capital and tax incentives, to the creation of a state backed fund in 2014 to invest in the industry. The fund would notably encourage mergers and acquisitions to improve efficiency, and would receive a boost to $29 billion in 2019.[100] According to analysts at the Daxue Consulting research firm, such state intervention would "play a key role in steering the overall strategy and investment in the integrated circuit sector, which includes processors and storage chips used in smartphones and data centers . . . China's ambitious goal is to create national champions in each semiconductor market segment. . . . China now supplies more than half the world microelectrics and hopes to build on this to create similar success in memory, CPU, and AI chips."[101]

STOPPING HUAWEI: SEMICONDUCTOR CHIP WARS

The increasingly apparent modesty of America's industrial base relative to that of China, particularly in the telecommunications field, was further

underlined by a major development in July 2020 which brought the US' ability to wage a tech war into further question. The Chief Executive Officer of California-based Intel Corporation, Bob Swan, raised the possibility at the time that the firm could stop manufacturing semiconductor chips. This came after the company's long anticipated ten-nanometer chip, its highest technology, had begun to enter high volume production several years behind schedule and as it was being announced that the new seven-nanometer technology was being delayed a whole year. As the Sanford C. Bernstein Co. brokerage firm's senior research analyst, Stacy Rasgon, observed regarding Intel's failings: "You didn't need to read any more. Whatever little credibility they had is out of the window." Shares lost 16 percent of their value the following day. This was a very significant development, as while the US was seeking to shore up Western firms to compete with China, Intel's decline threatened to leave the Northeast Asian region with an effective monopoly on production of the most advanced wafer fabricators and an even greater majority of the semiconductor value chain.[102] Following loss of dominance in semiconductor fabrication, a sharper decline in American firms' share of advanced semiconductor design soon afterwards became apparent with firms in Taiwan in particular, where 48 percent of global foundry capacity was based, fast cementing their primacy in design.[103]

Intel had been the largest manufacturer of semiconductor chips in the world for much of the past thirty years, and as the only large producer with factories still in the US it remained part the minority of America's non-military high tech manufacturing which had not been outsourced (see chapter eight). Its possible closure of chip fabrication lines represented only the latest development in a long trend toward decline, with the US share in global chip and microelectronics production having fallen from around 37 percent in 1990 to just 12 percent by 2021.[104] Where Intel was struggling to develop a 7nm chip, Huawei was that year already launching 5nm chips designed by its subsidiary the Shenzhen based HiSilicon fabless semiconductor company and fabricated by TSMC.[105] On the Chinese mainland itself, chipmakers UNISOC and SMIC respectively were preparing to put 6nm and 7nm chips into production.[106] In terms of sophistication the Chinese mainland's chip producers were drawing ahead of the United States and Western world, but still a way behind the world leader Taiwan where initial production of a 3nm chip was approaching ahead of schedule[107] and by mid-2021 a 1nm chip had been announced.[108] Intel was two to three generations behind TSMC,[109] something it openly admitted, which was the kind of disadvantage firms very rarely recovered from particularly considering broader economic trends in the US.[110] Indeed, TSMC's founding chairman Morris Chang had openly questioned whether the US could still provide engineers with the experience and skills needed to compete effectively in future generations of chips.[111]

Bloomberg referred to Intel's decision to even consider ceasing chip production as a move which "heralds the end of an era in which the company, and the US, dominated the semiconductor industry. The move could reverberate well beyond Silicon Valley, influencing global trade and geopolitics." It noted that most other US chipmakers had either closed down or commissioned firms in East Asia to make components for them, and that Intel's unique strategy among American firms of seeking to both design and manufacture semiconductors was "in tatters now" with its factories "struggling to keep up" with production processes for the latest designs. Chris Case, an analyst at the Raymond James investment bank, wrote in a research note that day regarding Intel's decline: "We view the roadmap missteps to be a stunning failure for a company once known for flawless execution, and could well represent the end of Intel's computing dominance."[112]

The crisis could not have come at a worse time considering the US government's renewed efforts to boost the domestic semiconductor industry, the lack of which could present a massive vulnerability for the country. Intel's chips ran computers which were used for a wide range of roles from designing nuclear power stations to drawing up new airplanes and spacecraft. Its chip production was expected to be outsourced to TSMC in future, with the Taiwanese firm producing semiconductors on a scale several times as large providing benefits which much smaller US-based production could not match. TSMC's engineers, according to a number of US sources, had overtaken their Intel counterparts in technical execution with the discrepancy only set to grow in future.[113]

A complete reliance on outsourced production presented a number of vulnerabilities for the US, with the possibility of a Taiwanese reunification with the mainland in the coming decades potentially placing the supply of chips firmly in the hands of its primary strategic competitor. Strong pro-mainland sentiments among much of the Taiwanese population meant sensitive technologies could often be compromised. These factors also affected defense cooperation, with several military analysts having warned against selling advanced combat aircraft to Taiwan due to the risks that their technologies could be compromised in one of these two ways, which was considered a primary factor leading the US to deny Taipei the right to purchase them.[114]

Washington responded to Intel's increasingly apparent failure to compete with desperate measures to ensure a domestic supply, primarily by placing considerable pressure on TSMC to set up a semiconductor fabrication plant in Arizona.[115] It was notable that when China had previously sought to entice foreign firms to manufacture in the country with a range of incentives in the 2000s, the US had objected that these practices were unfair at the World Trade Organization leading Beijing to abandon the effort.[116] The Arizona plant's

skilled workforce including R&D engineers, process engineers, equipment engineers, IT software engineer and others positions were almost all recruited and trained in Taiwan, with TSMC only being able to carry out the operation with free access to work visas which Washington assented to. This served as a strong indicator of the difficulties manufacturing high tech products in the US (see chapter eight), and signified that the only way to get cutting edge semiconductors made in America was to have an East Asian firm localize its production lines and its workforce.[117] The TSMC facility was reportedly intended primarily to meet the needs of the US military, which sought to avoid relying on chips fabricated abroad. The plant itself was far from exceptional. It would produce just 20,000 chips monthly while those in Taiwan produced hundreds of thousands, and would employ five-nanometer process technology which would be a few generations old by the time production was underway. While its commercial viability was questionable, with a low-cost effectiveness compared to production in Taiwan, the plant funded by the US federal government ensured the US military a supply of relatively advanced chips which could be sustained even in the event of war in East Asia or other disruptions.[118]

The Joe Biden administration moved the following year to provide over $50 billion to support Intel and related firms to strengthen the domestic semiconductor industry, although compared to spending by TSMC and Samsung this was hardly an exceptional amount. Samsung for example, which was several years ahead of Intel, was spending $116 billion to avoid falling too far behind TSMC.[119] Even with larger injections of funds, however, the prospects for American producers to compete in anything approaching the level of TSMC or Samsung were considered slim due to deeper deficiencies in the American workforce and industrial base (see chapter eight).

A number of factors appear set to give China a long-term advantage in the ‘chip war’ with the United States—a conflict as vital if not more so than any of the proxy wars of the Cold War-era and which was expected to have significant knock-on effects for both economies. As *The Economist* noted in December 2018: “The trade conflict that matters most between America and China is a twenty-first-century fight over technology. It covers everything from artificial intelligence to network equipment. The fundamental battleground is in semiconductors. The chip industry is where America’s industrial leadership and China’s superpower ambitions clash most directly.” The British magazine noted that in light of the emerging threat of Washington blocking China’s access to certain technologies to undermine the modernization of its tech sector, with semiconductors being particularly vulnerable, “China’s incentives to become self-reliant in semiconductors have rocketed.” It concluded that American efforts to this end “may be futile” in the long run, and at best could slow but not stop China’s rise to become a global leader in

key technologies. The US ultimately needed to "prepare for a world in which Chinese chips are more powerful and pervasive."[120]

While US efforts to bolster its chip industry increasingly fell flat, China's efforts to showed much greater promise. With these efforts accelerating as the US threatened further measures to cut Chinese firms off from key American supply chain inputs, a range of US sources predicted Washington's policies would only increase China's self-reliance and seriously harm America's own tech sector. As program vice president for enabling technologies and semiconductors at the market research firm International Data Corporation (IDC), Mario Morales, noted in mid-2019: "I expect the current tension between the US and China will only invigorate the spending in China on technology including software over the next five years."[121] By initiating hostilities the US may have only accelerated its own decline by pressing China and its suppliers to phase out reliance on both American inputs such as software as well as on US-made chips. As Editor of *International Trade Law News* Doug Jacobson had predicted when reports of new American restrictions first emerged in March in 2020: "This is going to have a far more negative impact on US companies than it will on Huawei, because Huawei will develop their own supply chain . . . Ultimately, Huawei will find alternatives."[122]

The Economist noted in 2018 regarding the precedent for this set by China's response to prior US semiconductor export restrictions which in 2015 had singled out Chinese supercomputer development for targeting: "Firms like Huawei have a proven ability to innovate; blocking the flow of Intel chips in 2015 only spurred China on to develop its domestic supercomputing industry."[123] Beijing's goal for 70 percent self-reliance in semiconductors by 2025 was backed by hundreds of billions of dollars of investment, a close private-public sector partnership and access to some of the world's foremost knowhow both from domestic institutions and from neighboring Taiwan.[124] As a longtime leader in semiconductor technologies, comfortably surpassing the entire Western world combined in productive output and sophistication, Taiwan emerged as a leading source of talent for China's semiconductor industry.[125] The decline of the Taiwanese economy, which worsened considerably under a new administration from 2016,[126] and the lack of significant language or cultural barriers, made the mainland highly attractive to Taiwanese talent ranging from television presenters to scientists. The result was a brain drain on a substantial scale as Beijing welcomed semiconductor experts in considerable numbers.

Warnings of a mass migration of Taiwanese experts to the mainland notably predated the Donald Trump administration's initiation of a tech war,[127] with former Vice President of Research and Development at TSMC, Lin Burn, having warned of the serious consequences for the territory's export-reliant economy. He stressed that "in such an environment, China

can gain more expertise while Taiwan will fall behind." Chief Executive of the world's third largest contract chipmaker United Microelectronics, Yen Po-Wen, similarly highlighted: "We do see China as a talent magnet as it is using national power to boost its chip industry. China has also been poaching our research and development engineers." Chairman of the world's leading memory driver integrated circuit supplier Taiwan's Phison Electronics, Pua Khein-seng, similarly observed: "Talent poaching is happening every day. Chinese companies love Taiwanese engineers because they are cheaper, more professional and responsible than Chinese employees." Taiwanese efforts to prevent this flow of key knowhow notably fell far short of success.[128]

Migration of Taiwanese chip experts to the mainland, while prevalent since the early 2000s, accelerated with the beginning of the tech war as the need to develop domestic industry became all the more imperative for China. Benefits offered to Taiwanese experts who relocated grew increasingly ludicrous, with Taiwan's *Business Weekly* reporting in 2019 that over 3,000 semiconductor engineers had left for positions in mainland firms. The figure was verified by analysts at the Taiwan Institute of Economic Research and represented approximately 8.5 percent of Taiwan's entire semiconductor industry workforce, with mainland firms often choosing the most valuable workers for recruitment. The *Financial Times* warned in December 2019 that this provided China's semiconductor industry with invaluable resources at a relatively low cost, citing the prominent example of the well-known 'godfather' of Taiwan's dynamic random-access memory industry, Charles Kao, who joined the mainland's Tsinghua Unigroup in 2015.[129] Another notable example was TSMC's former R&D director, Chiang Shang-yi, who was recruited by SMIC and advised mainland firms on how to more quickly advance their integrated circuit manufacturing.[130] A third was Liang Mong-song who, after leaving TSMC, had worked as Samsung's system LSI division chief technology officer before joining SMIC as its co-CEO in 2017.[131]

Mario Morales was among the many experts to highlight that the Chinese tech ecosystem had the potential to surmount the challenges posed by the American tech war through development of its semiconductor industry. He emphasized the importance of "talent that continues to move back into the region to drive more innovation and scale."[132] Research director at Counterpoint Research, Neil Shah, similarly postulated: "If China as a whole is able to acquire the right human resources talent, companies, and partnerships, it should still be on track to create a homegrown semiconductor industry over the next decade without access to American tech."[133] With the ratio of the world's best and brightest in the field working in China, relative to those working in the West, expected to continue to increase rapidly, the East Asian state, its tech sector, and Huawei were all well placed to surmount challenges posed by US interference in the medium-long term. Supporting

this process was the Chinese government, which emphasized developing greater self-sufficiency in core technologies such as semiconductors under its Fourteenth Five-Year Plan.[134] Huawei, ZTE, and other emerging tech firms which were likely to be targeted by Washington in future, all benefited from Beijing's recognition of the importance their industries had as it moved to safeguard the country's drivers of innovation from future hostile actions.

In April 2019 Huawei created a subsidiary named Hubble Technology (Habo) Investments which over the following year concluded seventeen transactions under which Huawei would finance the development and formation of other firms as part of an effort to support promising Chinese firms that had the potential to become future partners. The goal appeared to be to boost China's technological base in fields where it was favorable to avoid reliance on foreign suppliers. Huawei's rotating chairman Guo Ping confirmed that US attacks had stimulated thee firm to take such steps, stating: "Since Huawei is only one company, we use investment and technology to help our supply chain partners become mature."[135]

By the end of 2020 Huawei had taken stakes in twenty semiconductor-related firms over 18 months, with half of those deals coming in the preceding five months alone. In the latter half of 2020 the firm began building a small-scale semicondcutor production line for research purposes near its headquarters in Shenzhen. According to sources cited by Japan's *Nikkei,* the line's purpose was "to help accelerate chip development and to make sure all its designs can later be put into production smoothly." The paper reported, citing anonymous sources, that the Chinese government was helping Huawei seek out investment opportunities to help the firm overcome American efforts against it. According to the Japanese paper, through its investments Huawei "aims to step into any area that it lacks in chip development, from chip production, materials and equipment, to design software," with Habo Investment being a key facilitator of the elimination of foreign inputs.[136]

On October 31, 2020, the *Financial Times* reported that Huawei was planning to open a new dedicated chip manufacturing plant in Shanghai for research purposes. The plant would be run by the Shanghai IC R&D Centre chip research company. Since it would not be supplying Huawei with chips, and would at least initially be manufacturing for research, it would not be subjected to the same restrictions as Huawei itself on using American inputs. R&D was reportedly intended to allow Huawei to eventually secure supplies for its core telecoms infrastructure business without reliance on American software, initially producing 45nm chips for smart TVs before moving on to 28nm and then 20nm nanometer chips the latter which could be used in its 5G telecoms equipment.[137] Developing smaller chips for smartphones, however, would take considerably longer, with its most advanced handset at the time the Mate 40 Pro using the 5nm Kirin 9000.[138]

In the first week of December Huawei's first chipset manufacturing facility, the Wuhan Huawei Optical Factory Project, completed construction in the Wuhan Optics Vallery Centre. It was intended to eventually complete a semiconductor industrial chain which would also include testing, manufacturing and packaging, and would complement the facility already operating in Shanghai.[139] The following year Huawei put a new self-developed OLED driver chip into mass production, which acted as the main control panel in a system to manage a screen's image quality and energy efficiency. Although these represented a core technology, used in electronic gadgets like smartphones and televisions, Chinese producers had less than 1 percent of global market share with South Korean firms Samsung and Magnachip respectively holding 75 and 20 percent. Investment in producing more advanced OLED driver chips thus represented part of a broader effort to secure supply chains, which as was often the case required firms to compete in new fields.[140]

Such investments allowed Huawei to diversify its operations amid sustained US pressure, and also provided a means to enhance the differentiation competitiveness of flagship products to an extent that only Samsung had previously been able to due to its self-reliance in OLED driver chips.[141] Other moves to diversify more widely ranged from investing in producing electric vehicles,[142] a step Apple[143] and Google[144] among other competitors had also taken, to allowing rival smartphone makers to use its patented 5G technologies, of which it had more than any other firm in the world, for a royalty fee per handset produced.[145] The large number of patents also meant that large telecommunications companies such as Ericsson and Qualcomm would struggle to develop their own 5G-related businesses without Huawei's technology.[146]

Huawei's efforts to develop a semiconductor manufacturing capability benefited from the broader ecosystem of fast advancing semiconductor fabricating technologies in China that were independent of US inputs. Moves by the Chinese government in August 2020 to offer major tax breaks for chip design, packaging, testing and relevant equipment, materials and software enterprises further encouraged investment, with larger tax incentives notably offered to firms developing smaller chips.[147] Founder and CEO of Xiaomi Lei Jun, for one, announced in August 2020 that the firm was planning to produce new chip designs.[148]

In late November 2020, it was widely reported that breakthroughs in homegrown semiconductor development had brought Chinese firms close to being able to fabricate 7nm chips. Chip customization solution provider Innosilicon announced that it had completed testing of a prototype domestically fabricated chip. The Suzhou Institute of Nano-Tech and Nano-Bionics also announced a breakthrough in a new type of 5nm laser lithography technology in 2020, which could lay the foundation for development of machines

to fabricate chips of that size without relying on ASML. Although it was still expected to be many years before such a machine was operational, 5nm chips were a relatively new technology and the most advanced in the industry meaning even if production was only achieved after 2025 it would still be a very promising step toward greater self-reliance and significantly narrow the gap with TSMC.[149]

BLOWBACK FOR AMERICAN INDUSTRY

In August 2019 the US Commerce Department granted a 90-day extension to the Temporary General Licence reprieve to allow American firms continue to do business with Huawei for three months. It also announced, however, that more Huawei affiliates would be subject to bans on business. Commerce Secretary Wilbur Ross explained the move as follows: "As we continue to urge consumers to transition away from Huawei's products, we recognize that more time is necessary to prevent any disruption."[150] The extension was an effort to soften the impact that the ban on Huawei had on American firms. International trade policy expert at Rutgers University, Thomas Prusa, observed: "It seems fairly clear that the Trump administration is hearing from US businesses that his trade policies are hurting them, and Huawei is a valuable hardware supplier . . . It is a reminder that the global supply chain means many companies' performances are interlinked."[151]

Cybersecurity policy and China digital economy fellow with Washington-based think tank New America, Samm Sacks, stated to similar effect: "Failure to extend would cause massive disruption to rural broadband in the US, not to mention the slew of security issues from not being able to get software updates." He warned however: "this near-term stability may be an illusion. The extension just buys the administration more time on what may be an impossible task. There are some that want to dismantle Huawei altogether. Others wants to use it as leverage in a trade deal. You can't have it both ways."[152] Stephen Ezell, the Information Technology and Innovation Foundation's vice president of global innovation policy, similarly stressed that the extension was not a sign of détente, but rather intended to give US firms and telecoms networks more time to prepare for a broad and large-scale decoupling from Chinese industry that Washington envisaged.[153]

While moving to attack Huawei's chip supply, in May 2020 Washington notably amended prohibitions on US firms doing business with the firm to allow them to work together on setting standards for 5G networks. The new rule came in response to concerns from US firms and lawmakers, a person briefed on the matter told *Reuters*. Secretary Ross stated regarding this decision: "The United States will not cede leadership in global innovation.

The department is committed to protecting US national security and foreign policy interests by encouraging US industry to fully engage and advocate for US technologies to become international standards." "Confusion stemming from the May 2019 entity list update had inadvertently sidelined US companies from some technical standards conversations, putting them at a strategic disadvantage," said Naomi Wilson, senior director of policy for Asia at the Information Technology Industry Council, which represented companies including Amazon, Qualcomm and Intel. "This much-needed clarification will allow companies to once again compete and lead in these foundational activities that help enable the rollout of advanced technologies, such as 5G and AI, across markets."[154]

Chinese state media outlet *CGTN* described the move as "a very quiet and pragmatic concession that . . . the United States has failed to stop it [Huawei] from becoming a major player in the next generation of internet networks. Therefore, Washington is, like it or not, forced to recognize that if it wishes to have a stake in setting standards, it must work with the company rather than riding on the false hope it can shut it out." It further observed:

> conceding that Huawei will have a role in the setting of global 5G standards is an indication that the White House is now aware of the realities that are at play . . . Failing to get it blacklisted throughout the world, Washington is now resigned to the fact that the company will now dominate the standards of the next generation internet and therefore, it is now forced to ultimately work with it in doing so.[155]

In an apparent push to regain lost market share, in September 2020 the US government provided Qualcomm with permission to supply 4G chips to Huawei. While 4G chips were used in a shrinking percentage of smartphones produced particularly among high end flagship handsets, this exception appeared to be an arbitrary effort to boost Qualcomm's market share while its non-US rivals faced blanket bans on supplying Huawei.[156] China's second-largest mobile chip maker, UNISOC, had drastically accelerated plans to launch its first 5G chips and was scheduled to do so in 2020 to displace Qualcomm and other foreign suppliers and move into their market share.[157] As Qualcomm itself had warned the US government, export bans risked handing billions of dollars of revenues from annual sales to Huawei directly to any non-US competitors that could avoid Washington's restrictions.[158] Qualcomm was reliant on sales to China for close to 60 percent of sales revenues,[159] which was particularly high within an industry generally dependent on China as a client for 36 percent of all chip sales.[160] As editor of *International Trade Law News*, Doug Jacobson, had predicted in March 2020 regarding proposed measures to block chip sales: "This is going to have a far more negative impact on US

companies than it will on Huawei, because Huawei will develop their own supply chain . . . Ultimately, Huawei will find alternatives."[161]

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surprising that Hongmeng has a plan for adapting to the Qualcomm platform for a long time. Not only the Qualcomm platform, but also other platforms such as MediaTek will also have an adaptation plan. As an open source system, I find it strange that it doesn't fit. In addition, a lot of manufacturers have begun to accept Hongmeng, not only home appliances, automobile companies, but also some mobile phone manufacturers are also contacting, and have plans to adapt. As for which manufacturers will not be revealed for the time being, there will be surprises at that time. The pattern of the Android era does not represent the future. Huawei#数码迷##武汉##Huawei Hongmeng is expected to push on a large scale next month#], May 7, 2021.

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Chapter 6

America's Global War on Huawei

STOPPING HUAWEI: COERCION AND IDEOLOGY VERSES TECHNOLOGICAL SUPREMACY

US efforts to stymie Huawei and deny it contracts capitalized on longstanding depictions of China in Western media as a malign actor and imminent threat to the world, and largely depended on portrayals of the firm as an arm of some form of malign Beijing conspiracy for global domination. As ludicrous as this may have sounded, it was not totally ineffective with Western portrayals of China since 1949 as both a 'Red Terror' and a 'Yellow Peril'—a menace because of its communist government and its Asiatic culture—having effectively set the stage for Huawei's vilification. Western claims that Chinese-built telecoms infrastructure posed a risk to the security of its users were repeatedly dismissed by both Huawei representatives and the Chinese government. One of the telecoms giant's several statements to this effect claimed in response to being banned from a European country under this pretext: "Huawei is a private commercial company 100 percent owned by its employees. There are no factual grounds to support any allegations of Huawei posing any security threat. We find the exclusion of Huawei simply based on groundless presumption, unfair and unacceptable."[1]

As China's economy emerged as a leader in high end technologies with products which outcompeted their Western counterparts with growing frequency, officials and media outlets in the West and in the US in particular increasingly emphasized that economic interests needed to be superseded by ideological ones. This was voiced particularly distinctly by the Speaker of the United States House of Representatives Nancy Pelosi, who described efforts by a private Chinese firm to bid for contracts to develop 5G networks across the world in the harshest conspiratorial terms. "This is the most insidious form of aggression, to have that line of communication, 5G, dominated

by an autocratic government that does not share our values," she stated at the Munich Security Conference in February 2020. What was strongly implied was that only countries which had adopted Western values and had Westernized political systems should be allowed to operate internationally at the high end of the telecommunications industry.[2] Pelosi further stressed the point that ideology rather than technology should form the basis of countries' choices, likening working with Huawei to "choosing autocracy over democracy"—the latter presented as the ideology 'good west' and the former the ideology of the 'malign Asian state.'[3]

Pelosi instead called on countries to support US-led efforts to catch up to Huawei in order to ensure that a country with Western values rather than an East Asian one was at the forefront of 5G technology.[4] Chairman of the US Senate Select Committee on Intelligence Marco Rubio similarly exemplified the trend toward relying on ideological arguments against Huawei, claiming that allowing the company to compete fairly for contracts risked "enabling Beijing's digital authoritarianism." Referring to Huawei's successes as "technological imperialism," Rubio claimed that Chinese domestic policies, including Western allegations of human rights abuses in Hong Kong and Xinjiang province and alleged mishandling of the COVID-19 crisis, were viable pretexts to effectively ban a non-state telecommunications firm from operating. Like Pelosi and many others, he called for collaboration among Western powers to develop a viable alternative which would supposedly reflect the ideology and value system of the Western world.[5] While ideology did not affect how Huawei was run, it provided grounds to vilify its country of origin as 'the other' and the telecoms firm by association.

Such calls for measures against Huawei and for government intervention to create a Western competitor were echoed widely in the US in particular, on the basis that the leaders in 5G had to be American, Western, or at the very least politically Westernized. Realizing this goal, however, would pose near impossible due to the vast technological discrepancy between Huawei and its lagging Western competitors. As the *Wall Street Journal* noted in the headline of a prominent article in November 2020: "US vs. China in 5G: The Battle Isn't Even Close." Emphasizing that China was "leading the way in the size and consistency of its 5G network," it stated to this effect:

> China has more 5G subscribers than the US, not just in total but per capita. It has more 5G smartphones for sale, and at lower prices, and it has more widespread 5G coverage. Connections in China are, on average, faster than in the US, too. When it comes to the things that are supposed to make 5G revolutionary, not just evolutionary—the apps made possible by the greater speeds and capacity—China's front-runner status is less well-entrenched. For both countries, supposedly life-changing 5G applications, like self-driving cars, remote

> surgeries and automated factory floors, are still years away from widespread use. However, China's lead in 5G-network rollouts could set it up to pull ahead in this respect as well.[6]

5G networks in China further had the advantage that the government had made a mixture of low-band, mid-band and c-band spectrum frequencies available from an early stage. Low-band spectrum frequencies in the 600, 800 and 900 megahertz bands could transmit signals over longer distances, penetrate through walls of buildings and provide better indoor coverage, but carried less information. The mid-band spectrum was complementary, and in the 2.5 and 3.5 gigahertz range it could cover a several-mile radius. C-Band, at 3.7 to 4.2 gigahertz, supported high-capacity broadband and enabled advanced applications like augmented and virtual realities without line-of-sight challenges. Chinese firms could thus familiarize themselves with all bands from an early stage. In the US, by contrast, the Federal Communications Commission was very slow to provide licenses for anything higher than the low-band spectrum, meaning the initial 5G rollout was restricted to the millimeter wave spectrum which had a very short range not much larger than a powerful Wi-Fi hotspot. Congress, too, was slow to allow legislation to pass which would facilitate the process of getting a wider spectrum for 5G use approved. US bureaucracy was cited as a factor which slowed down the process for getting a greater spectrum to market.[7]

Another impeding factor was that the US reserved a wide range of valuable mid-band frequencies for military use, in contrast to China where commercial and civilian uses were given a greater priority.US prioritization of the military thus effectively impeded its 5G rollout. *Politico* described the issue as the Pentagon "sitting on a chunk of valuable airwaves"—ones it was reluctant to share. "As they bicker, Chinese companies aren't waiting . . . and US producers fear that they're being shut out of a quickly developing new technology by their own government," it observed regarding efforts to get the Pentagon to share its wavelengths, with China's equipment in the meantime quickly becoming the industry standard across the world. The military's actions were criticized on the basis that "by squatting on the rights it is blocking American firms from developing better 5G networks . . . And, with China racing to exploit its lead, the lack of mid-band open to American companies is raising a bigger worry for US competitiveness: Even if the Pentagon finds a way to free up some of the territory, China's growing head start may mean it's already too late."[8]

Regarding how the military viewed calls to give up parts of the spectrum, former defense secretary under the Obama administration Ashton Carter had stated that the Pentagon: "needs to defend vigorously the parts of the spectrum that it really needs. Because once you give them away you'll never get

them back." He highlighted that it was not possible to predict which wavelengths the military would end up needing—meaning valuable ones were reserved for military use but were not actually being used.[9] With moves by telecoms companies to gain access to vital mid-band frequencies facing stiff Pentagon resistance, the needs of which were given a far higher priority in the US than in most developed countries, a resolution was expected to take several years. Divisions between telecoms carriers on how potential access to the mid-band spectrum should be shared, and conflicting plans pushed for by differed lobbying groups, only further worsened the situation.[10]

China's lead in 5G was massive when measured both quantitatively in terms of how widespread it was, and qualitatively when comparing Huawei to its competitors. The country was projected in 2020 to have 690,000 5G base stations—the radio receiver/transmitter equipment fitted to masts—operating by the end of the year compared to just 50,000 in the US.[11] China exceeded this projection that year, had average 5G speeds five times as fast as the US, and had 150 million 5G users while America had just 6 million.[12] Describing China's lead in more triumphalist terms the former head of the American tech giant IBM's Fintech Innovation Lab, innovation expert and AI consultant Richard Turrin, referred to China's newfound primacy in 5G as a "Sputnik moment for the US."[13] He was far from alone in comparing China's 5G lead to the Sputnik launch.[14] Turrin further stated regarding China's position in the field:"It is an affront to the US because for the first time it sees that it is not at the center stage of advancing the world's technology and that it has to share this with China. It is a fundamental change in role, that is, frankly, technologically frightening for Washington . . . So, at some existential level the US feels threatened when Chinese technology is being used to replace their own."[15]

As was seen with 4G, the countries that led in development and employment of the latest technologies very consistently gained more economic growth from them—in what is otherwise known as the 'First Mover Advantage.' American leadership in 4G, for example, contributed approximately $125 billion in US company revenues from abroad and more than $40 billion in US application and content developer revenue, and created 2.1 million new jobs from 2011 to 2014.[16] This made the extent of China's lead in 5G particularly concerning to supporters of US and Western primacy, with the new technology's importance and its knock-on benefits across the economy set to far exceed those of 4G.[17] As noted by the *Financial Times* among others, the Chinese economy's first mover advantage in 5G was only further amplified as the US and many of its partners moved to ban Huawei which meant that 5G would reach them considerably more slowly and at in inferior quality that it would have otherwise due to the firm's clear lead in the field.[18]

Regarding American efforts to press countries not to work with Huawei, Richard Turrin noted: "It is shocking to see the US leaning on its allies . . .

who are ready to roll out on 5G and they're ready to go with Huawei and the US says please don't . . . If the US had a competing product, they could at least make the argument that 'buy US-made 5G equipment, don't buy Huawei.' I get it. That would be a very simple commercial argument. But the US doesn't make a competing product."[19] Highlighting that American wireless networking firms had "failed to keep pace with a changing market," and had been falling behind for two full decades, the *Washington Post* noted to similar effect: "The absence of a major US alternative to foreign suppliers of 5G networking equipment underscores the growing dominance of Huawei, which has evolved into the world's biggest supplier of telecom equipment."[20] The extent to which the US was forced to rely on political pressure and ideological arguments reflected the serious degree to which it, and the Western world more broadly, were behind in telecommunications technologies.

Aside from the fact that China had displaced the US as the largest trading partner for most of the world, diminishing Washington's leverage in the process, and beyond the unconvincing nature of American allusions to a security threat, the lack of any near-peer Western competitor in 5G infrastructure remained a key weakness in US efforts to press countries to avoid Huawei. As the *New York Times* observed, because the US had produced no viable alternative "American efforts to get countries around the world to excise Huawei from their telecom networks have been largely unsuccessful."[21] Those countries which did give in to Washington's pressure and arbitrarily banned Huawei faced not only prospects of a deterioration of relations with the world's largest economy—which in most cases was for them a larger trading partner than the US—but they would also be relegated to the 5G 'slow lane.' By contrast, those countries which chose 5G contracts on the basis of performance rather than politics would see their firms, and their economies more broadly, enjoy important advantages over those which did not including key first mover advantages for their own tech firms.

STOPPING HUAWEI: AMERICAN PRESSURE VS. THE WORLD

The alleged but unevidenced security threats which the US claimed Huawei posed were generally seen to be far from convincing, particularly in light of the NSA's failure despite deep penetration of the Chinese telecoms giant to find any proof of malign activity by Huawei or of collaboration with Chinese security services. As a result the US increasingly began to rely on the use of threats and intimidation to press countries not to use Huawei equipment. *Time* in May 2019 referred to the often-threatening American coercive measures as an effort to "drive a wedge between Huawei and the rest of the world,"[22]

with *Reuters* in November describing the US as having "piled pressure on its allies . . . to shut out Huawei Technologies."[23]

A notable example was Brazil, a leading potential market for 5G infrastructure, where in the final week of July 2020 the US ambassador Todd Chapman threatened that the country would face "consequences" if it used Huawei equipment in its 5G network.[24] Whether Brasilia would comply remained uncertain, with its militarist leadership prone to strongly supporting Western initiatives and to taking a hard line anti-Chinese positions to win popular support amid entrenched and rising sinophobia in parts of the Latin world.[25] According to *Reuters*, citing anonymous sources in December 2020, Brazilian President Jair Bolsonaro was personally pressing for a means to block Huawei.[26] This followed a history of anti-Chinese sentiments expressed by the president, while his son Congressman Eduardo Bolsonaro made comments against Huawei which were seen as provocative and unfounded in both Brazil and China.[27] With China remaining Brazil's largest trading partner, however, Bolsonaro faced strong resistance from within his government and from industry.[28] This resistance remained despite a US offer of $1 billion financing if Huawei was blocked.[29]

Chinese investment was key to supporting Brazil's troubled economy, and an arbitrary American-style ban on Huawei would have risked compromising this relationship.[30] Huawei equipment was already widely used by major Brazilian telecoms firms in 3G and 4G networks, including 65 percent of the equipment used by Telefônica Brasil and 60, 55 and 45 percent of that used by Oi, Claro and TIM respectively. The COVID-19 induced lockdown only increased demand for Huawei equipment in 2020 as internet usage surged. The lack of a legal premise for the kind of arbitrary restrictions both Bolsonaro and Washington were pressing for, the potential fallout for relations with China which were key to Brazil's economic health, and likelihood of very significant delays to Brazil's telecoms infrastructure modernization, all served to rein in the possibility of discrimination against Huawei.[31]

The Faroe Islands, known as a world leader in the speed of its internet connectivity, was an example of a much smaller state where Western political intervention sought to derail what was otherwise a natural partnership with the world's leader in 5G technologies. *Politico,* for one, dramatically referred to Huawei as having "conquered the Faroe Islands," highlighting that Western intervention "may derail the Faroese 5G rollout—forcing the island nation to pick between its state-of-the-art phone system and European political priorities." The state-owned Faroese Telecom company had previously worked with Huawei for four years, and already had a pilot plan to be among the first in the world to roll out 5G. Jan Ziskasen, Faroese Telecom's CEO, highlighted that should the country be forced to remove Huawei equipment

and end cooperation with the Chinese firm it "would be set back by years" and make very significant financial losses. Alluding to the issue emerging as a result of the trade war between Washington and Beijing, Ziskasen stressed that there was an absence of "solid proof" to substantiate US allegations that Huawei posed a security threat, and indicated that Faroese Telecom would continue to cooperate with the Chinese firm unless evidence was provided.[32]

Beyond the Faroe Islands, small countries with close economic ties with the Western world were particularly vulnerable to potential retaliation should they work with Huawei to increase connectivity using 5G. A notable example was Jamaica, which was threatened in October 2020 with a hard hit on its financial sector if it purchased 5G technologies from any Chinese source. US ambassador Donald Tapia continued the prevailing trend among American officials of couching arguments in strongly ideological terms, stating as his rationale for Jamaica to ban Chinese offers that the "totalitarian nature" of the Chinese government and its lack of a Western-style political system meant its private firms should not be allowed to compete. "As for consequences, it's gonna affect banking, any financial transaction from this island, that's the biggest consequence you have, that your financial institutions and the finance of Jamaica stops . . . that's the consequence that you are looking at long term. That's major." The ambassador also warned that if Jamaica chose "to look to the East to the two-headed dragon," it would not be provided with American support for disaster relief for any earthquakes or hurricanes it may have. He called on Kingston to follow the example set by Britain earlier in the year to impose a total ban and work exclusively with Western suppliers instead.[33]

Several African states, including many considered in the Western sphere of influence, notably ignored Western pressure to ban Huawei and by late 2020 had begun to take steps toward introducing its 5G infrastructure. Seychelles[34] and South Africa[35] were the first on the continent to launch 5G networks with Huawei, with the latter's President, Cyril Ramaphosa, slamming Western efforts to undermine the telecoms giant which he referred to as "an example of protectionism" that disrupted efforts to modernize infrastructure. Huawei, in his words, was targeted "because of its successes."[36] Algeria, Angola, Cameroon, Egypt, Gabon, Kenya, Namibia, Senegal, Tunisia and Uganda, were expected to be the first follow, with many having already tested 5G in collaboration with Huawei or signed memorandums with the firm over 5G.[37]

The African Union itself had long maintained close partnerships with Huawei on a range of technologies, and this was renewed in May 2019 covering fields including 5G, broadband, cloud computing and artificial intelligence among others.[38] Africa was the second largest mobile market in the world only to Asia, with many of its national markets among the world's fastest growing. The continent had 250 million smartphone users in 2017, and the number was expected to reach at 440 million by 2025.[39] While not as

profitable as markets in East Asia or in much of the Western world, access to African markets still represented a serious gain which would yield growing dividends for decades. Due to an overall lack of political leverage to push countries away from Huawei, Western rivals struggled to compete.[40] A similar trend could be seen across South America, Central Asia and the Middle East.

By the end of 2020, countries outside Africa which had adopted Huawei 5G technologies or formally agreed to do so included Bahrain, Bolivia, China, the Faroe Islands, Iceland, Kuwait, Lesotho, the Maldives, Mexico, Monaco, Oman, the Philippines, Saudi Arabia, Serbia, South Korea, Turkey and Qatar. Many others, including Argentina, Cambodia, Kazakhstan, Indonesia, Laos, Malaysia, Myanmar, Pakistan, Peru, Russia, Sri Lanka, Uruguay and Venezuela were expected to begin to shortly commission Huawei to develop their 5G infrastructure. Countries which had entered into 5G partnerships with Huawei included many which were closely aligned with the US such as Saudi Arabia, Turkey and Iceland,[41] and the firm's market share for 5G infrastructure had grown throughout 2020 despite Washington pulling out all the stops in the campaign against it—as had the market share of ZTE. As some analysts claimed that the world was being split between those who followed the US lead to ban Huawei infrastructure, and those which did not, the West appeared increasingly isolated.[42] *The Hill*, for one, observed in October 2020 as one of many indicators that China was "winning the war for global tech dominance": "Unfortunately for those hawkish on Huawei, the vast majority of the world remains open to using the company's technology. Huawei has a presence in more than 170 countries . . . This is a reflection of the reality that America finds itself in today—namely, that China appears to be winning the war to build the world's technology infrastructure."[43]

Huawei's global market share by the end of 2020 was greater than that of Nokia and Ericsson combined, and it had no near-peer competitors in the global penetration of its 5G infrastructure.[44] Its lack of access to several the largest economies in the West due to political interventions was still a major blow to its operations, however, considering the much wider penetration its highly competitive products would otherwise have had. Beyond 5G, Huawei was having considerable success marketing other forms of infrastructure abroad including cloud infrastructure and e-government services, for which it implemented contracts in at least 41 countries by mid-2021 in the preceding fifteen years usually with multiple contracts in each country.[45] Even for non-5G contracts, however, potential clients faced considerable Western coercion. A notable example was Huawei Marine's bid for the Kiribati Connectivity Project, a regional submarine cable system connecting Kiribati, with Nauru, Kosrae and Pohnpei in the central Pacific. The Federated States of Micronesia received an official warning that it was expected by Washington to choose Finland's Nokia or Japan's NEC and to reject Huawei's bid.[46]

An analysis written for the *Asia Times* was among several which described the world as "spitting into pro and anti-Huawei camps." While Huawei generally made the best offers for 5G, usually by a considerable margin over its competition, American and Western political clout was tested against economic pragmatism which did effectively divide the world in two on the issue. As prominent American AI consultant Richard Turrin noted: "the ensuing battle for 5G supremacy between China and the US will divide the world in two distinct digital spheres of influence."[47] The hard line drawn by the US and its partners disrupted the competition for 5G contracts which was supposed to be based on technology and performance by issuing threats and strongly emphasizing the introduction of political connotations and ideological affiliations to the process to try to compensate for Huawei's overwhelming performance advantages.

Some very close American security partners which notably ignored Washington's pressure and allowed Huawei to compete fairly for entry into their networks included Bahrain, which was the base of the US Navy's 5th Fleet,[48] South Korea which hosted the third largest contingent of overseas US personnel,[49] and Hungary. Despite being an EU and NATO member, Budapest was often at odds with the remainder of the Western world over interference in its domestic affairs and resisted pressure to take a hard line against Beijing on a number of issues.[50] In 2021 Washington sought to press the United Arab Emirates to abandon Huawei's 5G and reduce economic engagement with China by threatening to withhold access to F-35 next generation fighter jets, which was an asset Abu Dhabi had for years lobbied strongly for access to. The result, however, was that the country abandoned talks for F-35s to purchase French Rafale aircraft, which although less sophisticated came with no similar conditions attached, to continue doing business with Huawei.[51]

A deal in the world's seventh largest economy and sixth largest internet user[52] Indonesia in December 2020 was seen by analysts to be key to maintaining Huawei's momentum after concerted US efforts to stymie its growth that year. The deal was described as spearheading a 'push for Southeast Asia,' and involved developing Indonesia's own 5G technology and related fields including assisting the Indonesian Presidential Staff Office in putting 100,000 officials through a five-year digital literacy training course which offered access to Huawei's own internal knowhow. The Chinese telecoms giant was also assisting Indonesia's second largest telecom carrier, Indosat Ooredoo, to install 5G infrastructure in the country's Jakarta capital region with other regions expected to closely follow.[53] The Indonesian government by the end of 2022 had many more collaborative "strategic projects" centered around Huawei technologies planned.[54]

Winning over Indonesia was no small feat. The country had been prone to extreme Sinophobia in the past, with mass lynchings of its Chinese ethnic minority occurring on multiple occasions in the twentieth century as recently as the late 1990s.[55] In 1965 Jakarta had completely cut diplomatic ties with Beijing following a Western-backed military coup, and had only formally resumed ties in 1990.[56] According to Indonesian analysts: "The government of President Joko Widodo views collaboration between Huawei and Indonesia's technology industry, government, and universities as central to achieving its goal of producing a creative and digital economy by 2035 and a 'more developed' nation by 2045." As a result, Huawei was "welcomed with open arms" by Jakarta, with close collaboration with China taking place in 5G, artificial intelligence, and cloud computing.[57] According to Indonesian officials, Huawei supported public education on the potential benefits of 5G and helped accelerate the digitalization of infrastructure. The Chinese telecoms giant also pledged to develop infrastructure such as band transceiver stations to facilitate wireless communication across the Indonesian islands so that the benefits of 5G technology could be accessed widely.[58] Alongside 5G, Huawei had been highly successful in Indonesia's smartphone market with Chinese brands collectively holding over 70 percent market share by the end of 2020.[59]

American analyst Meaghan Tobin was one of many to highlight that the fact that Huawei's technologies would drive the spread of 5G in Southeast Asia was "a slap in the face to a US that has been trying to poison the well against its Chinese competitor." Following major gains by Huawei in Malaysia's 5G market, Tobin highlighted in April 2019:

> Malaysia is just the latest in a string of Southeast Asian nations to have welcomed the world's largest telecommunications company with open arms . . . It's not just that countries in Southeast Asia are less suspicious of China's motives. Many have been seduced by its technological prowess. Huawei claims a twelve to eighteen month advantage over its competitors, promising those who sign up to its technology the fastest and most advanced 5G networks in the world. And not only is its technology more advanced that its Western competitors, it comes at a fraction of the cost—especially for those nations already using Huawei technology in their existing communications infrastructure. [60]

By this time Huawei estimated it would have 80 million customers in the region within the next year and $1.2 trillion of business opportunities over the next five, with Thailand already carrying out joint research with the firm and with Singapore's M1 service, Malaysia's Maxis and Indonesia's Telkomsel having all signed up to trial services. The Thai government and Huawei in 2021 partnered to launch Southeast Asia's first 5G smart hospital.[61]

Even in the Philippines, a former US colony and longstanding Western client state, Huawei was selected to install 5G infrastructure.[62] The Chinese firm's presence dated back decades, with the Philippines' leading telecoms firm Globe Telecom running its 4G networks entirely on Huawei equipment and rolling out 5G from June 2019.[63] As Globe Telecom's senior vice-president for corporate communications, Maria Yolanda Crisanto, observed: "From a pure technology perspective, Huawei is ahead of its competition. Huawei is a global technology leader with a full range of products to serve our needs [and this is] enjoyed by Globe customers."[64] Globe's chief executive Ernest Lawrence Cu undermined American claims of a security threat, saying Huawei had been given a "clean bill of health" by British and Israeli consultants hired to check whether its networks were secure. "They may provide the equipment, but we run the network and so we know what passes over our network, what goes through it . . . we're very confident that we're well protected," he told *Bloomberg*.[65]

Huawei's importance to Southeast Asia's infrastructure modernization, and the lack of viable alternatives in many cases, was stressed by Singaporean correspondent Bhavan Jaipragas in a prominent article titled: "If Donald Trump kills off Chinese firm Huawei, do Asia's 5G dreams die?" He was among several analysts to conclude that Huawei was indispensable for Southeast Asia's infrastructure modernization, and that much of the region would struggle to adopt 5G without it. In part as a result, the region's major regulators and telecoms firms "shrugged off the West's concerns," with Huawei "widely lauded for being far ahead of Western competitors in developing 5G."[66] Experts widely observed to similar effect that Southeast Asia was "a corner of the globe where the US has already lost its propaganda war" by failing to vilify Huawei.[67] The Chinese firm had built up resilient partnerships across the region relatively inconspicuously since the 1990s,[68] hence why Huawei officials stressed that they had "proven ourselves with a twenty-year cybersecurity record in Southeast Asia," and largely as a result American coercion and allusions to a 'China threat' had little impact.[69] Partnerships had included Huawei investing in social programs and development initiatives, supporting local talent and research, and even providing disaster relief. China's status as a developing country was seen by many to have placed Huawei in a much better position to meet the needs of Southeast Asian communities, which helped strengthen relationships with governments and local communities.[70] Amid broad Western efforts to press Southeast Asian countries to take a hard line against China, Chinese firms, and Huawei in particular, there was thus a broad trend toward rejecting Western attempts at coercion.[71]

Huawei's superiority over its competitors in 5G and its popularity with local telecom operators across the world was such that even in India, which had initially moved toward following the positions of its QUAD strategic

partners the US, Japan and Australia, a reversal meant Huawei was included in 5G rollout working groups. This decision was made by India's Department of Telecommunications, with the country's telecom operators having urged government through groupings such as the Cellular Operators Association of India to allow Huawei and ZTE to be part of the country's 5G rollout. Among both telecoms industry executives and government officials skepticism regarding American claims against Huawei and perceptions of geopolitical motivations for Washington's campaign against it, combined with the very real advantages offered in terms of both price and performance, fueled support for partnerships with the Chinese firm.[72] India had no real alternative to working with Huawei if it wanted to avoid delays to its 5G rollout, and as a result it continued to resist significant and sustained American pressure to enact an arbitrary ban.[73] These decisions were made despite ongoing tensions on the Sino-Indian border. The value of access to India's very large wireless market was not lost on a several analysts—a prize rivaled only by the American market and the domestic Chinese one.[74]

Even in the West itself portrayals of a 'China threat' took time to have an effect leaving many states and firms reluctant to make economic sacrifices and alienate the world's largest economy under American pressure. As adjunct senior fellow with the technology and national security program at the Centre for a New American Security, Elsa Kania, observed in a prominent article in *Politico* in February 2020: "American attempts to browbeat allies and partners into shunning the company's equipment have proved ineffective. When it comes to countering Huawei's dominance, White House officials have offered a disorganized assortment of options to respond, and often muddled the messaging."[75] New Zealand was one notable example, and after indicating in 2018 that it would impose arbitrary restrictions on Huawei, its government announced early the following year that Huawei had not been ruled out from a role in the country's 5G plans.[76] Its second largest mobile carrier Spark later that year indicated it could procure Huawei equipment for integration into its 5G network alongside equipment from Samsung and Nokia.[77] The head of New Zealand's Government Communications Security Bureau, Andrew Little, in July 2020 ruled out an arbitrary ban.[78]

Britain was another notable example indicating the kind of difficulties many countries faced when caught between trying to appease Washington and the need to modernize telecoms infrastructure. London initially sought compromise by capping Huawei's role in 5G networks at 35 percent and excluding it from sensitive parts of its 5G grid, although this was firmly rejected by Washington which required a zero-tolerance line against Chinese 5G despite the serious delays and financial losses this would cause. In January 2020 Washington expressed strong disappointment in London's decision to allow Huawei a limited role in British 5G networks.[79] US officials pledged to

work "with the U.K. on a way forward that results in the exclusion of untrusted vendor components from 5G networks," with the result being several months of further American pressure on its closest ally to change course.[80]

PRAGMATISM VS. IDEOLOGY IN BRITAIN'S CHOICE OVER HUAWEI

In a challenge to American-led coercive efforts, Huawei was approved to build an optoelectronics chip research and development center in Cambridgeshire in the United Kingdom in June 2020 and pledged to invest £1 billion (approximately $1.3 billion) in the first phase of construction. The telecoms giant planned to employ 300 to 400 people at the 50,000 square meter site, which would serve as the international headquarters of its optoelectronics business.[81] The United States government and many in the British government itself had notably lobbied to oppose the project, with the US State Department asserting that China's "authoritarian" non-Westernized political system, as well as its alleged lack of either human rights or the rule of law, were grounds to oppose involvement with a private Chinese telecoms firm. Tech contracts, it implied, should be offered based on the ideology of a bidding firm's country of origin regardless of the actual technologies on offer.[82] Similar pretexts were given by some British institutions for measures against Huawei, most notably Oxford University which consistently stood out for taking hard line stances against China[83] and had suspended all new research grants and donations from the tech giant as early as January 2019.[84]

The scale of Huawei's investment in Cambridgeshire was interpreted by analysts as a signal to the British government regarding the importance of and unique opportunities provided by Chinese investment to its struggling economy. Ideological convictions and external political pressures aside, Huawei had played a major role in Britain's telecoms network since the mid 2000s, and in April 2005 had won a large part of a £10 billion ($17 billion) project to replace sixteen of Britain's national phone networks with a single digital one.[85] A report from the *Financial Times* in January 2020 shed light on the true extent of the costs involved in taking arbitrary action against Huawei as Washington was demanding, with its prominent article titled "Barring Huawei from Britain's 5G is too costly to justify." It warned that economic repercussions would be broad, "holding back the UK tech industry," and would hinder the development in services with time-critical functions such as self-driving cars. "Banning Huawei from even the periphery would force operators to rip its equipment out of current networks—causing disruption, expense and delay—and [to] wait for other suppliers to catch up with its technology," it concluded.[86] This 'rip and replace' process was highly cumbersome as well as

costly. It entailed removing hardware from 12,000 of British Telecom's (BT) mobile masts across the length and breadth of the country in a process beset with issues such as obtaining landlord permissions and sealing off roads.[87]

On July 9 Vodafone and British Telecoms warned that it would cost billions of pounds in additional expenses if the British government banned Huawei, with just the reduction of usage of Huawei equipment implemented under US pressure having already been very costly. Vodafone UK's head of technology, Andrea Donà, warned British lawmakers that "an ultra-aggressive imposition of a change in policy could hamper our economic recovery in the UK," which she highlighted was the last thing the country needed in the midst of a serious COVID-19 induced economic crisis.[88] British GDP had just seen a 21 percent contraction in the second quarter, which was the worst on record and by far the highest of any major Western economy,[89] with the Bank of England beginning to consider the formerly unthinkable option of negative interest rates due to the seriousness of the crisis.[90] British Telecoms' chief technology and information officer Howard Watson warned lawmakers that if the British government were to take radical action and demand a removal of Huawei equipment by 2023, the country would face data blackouts. Donà corroborated this and warned signal black spots could last for days at a time.[91] By that time in mid-2020 Huawei had already installed 20,000 5G base stations across the United Kingdom.[92]

The debate over Huawei highlighted the contradiction in Britain's identity and its view of its place in the world after leaving the European Union. Was it a pragmatic trading nation—a 'Singapore of the Atlantic'—which would need to maintain positive relations with the world's largest and fastest growing economy China?[93] Or was it first and foremost a part of the wider Western world that aligned itself by ideology, which required it to be hard on the primary challenger to Western-led world order and thus shun Huawei for its Chinese origin.[94]

Despite the considerable costs involved, support for a more through purge of Huawei technologies from Britain's infrastructure grew within the country's leadership after it became increasingly clear that Washington would downgrade security ties and take a harder line on future trade agreements if London did not follow its orders.[95] The US subsequently imposed harsh export controls on Huawei designed to restrict the company's access to semiconductor chips made with American inputs in May, which was seen by some analysts as sending a strong signal to London regarding its intentions.[96] Just days later in early June Britain's National Cyber Security Centre launched an emergency review into whether Huawei's telecoms equipment should be used in British networks. That month the former head of MI6, John Sawers, called for harsher restrictions on Huawei.[97] The chair of the House of Commons Defense Select Committee Tobias Ellwood also supported a revaluation of

the issue, on the basis that Britain's disagreements with China's internal policies relating to COVD-19 and ongoing unrest in Hong Kong provided a greater political pretext to block the private Chinese firm from 5G contracts.[98] The country's main opposition party the Labour Party also took a harder line against China and Huawei, and to a greater extent that the ruling Conservative Party its members advocated policies influenced by ideological factors rather than pragmatic economic considerations. Britain's shadow foreign secretary Lisa Nandy, Labor's leading foreign policy official, stressed that the country needed "far greater strategic independence from China, which means that we need to have home-grown alternatives for our 5G network and our nuclear[99] power."[100]

On July 14 plans were announced by London to completely purge Chinese equipment from British 5G networks within seven years—a decision hailed by the US in ideological terms as a step toward "protecting free world values."[101] This would not only cost the country at over £7 billion (more than $9 billion), but it would also delay its 5G rollout by at least three years.[102] With Britain already using a great deal of 4G infrastructure from Huawei, much of which could otherwise have been upgraded to support 5G, this would be disposed of to start totally afresh with a new provider.[103] Huawei equipment already accounted for around 44 percent of the equipment used in providing super-fast full-fibre broadband connections directly to British homes, offices and other buildings, and efforts to reduce this would require use of less competitive products from Western producers including Finland's Nokia and America's Adtran. Even the previous goal of reducing reliance on Huawei equipment to 35 percent was expensive, time consuming and made little financial sense, and more radical steps later adopted would be considerably more costly still.[104] Matthew Howett from the London-based analyst firm Assembly, which had written a report for Mobile UK on the potential impacts of removing Huawei, noted:

> It's not only a very expensive process for the operators, but it's going to be a time-consuming one as well because they need to get access to all those sites to make the changes. And Huawei has been very innovative at coming up with the smallest and lightest 5G equipment, meaning the operators can sometimes just use a cherry picker to hook it onto existing mast infrastructure. Some of the others' is heavier and bulkier, which can require more in terms of getting planning consent and road closures.[105]

The Centre for Policy Studies think tank, which had been co-founded in the 1970s by then-cabinet member Margaret Thatcher to promote free market policies and was closely affiliated with Conservative Party parliamentarians, projected the costs of banning Huawei in an assessment published on October

1. These included shortfalls to connecting 11 million homes across Britain up to 2027 and costs of over £41 billion, among a range of other serious consequences.[106] On October 28, a report published by Assembly projected that arbitrary action against Huawei would significantly worsen Britain's already highly tenuous economic situation. Banning the Chinese telecoms giant placed approximately £100 billion in economic benefits and over 350,000 jobs outside London and the Southeast of the United Kingdom at serious risk. The fallout from the ban would cost British citizens £6,000 per household by 2030, and would affect not only the tech industry and tech hubs but also white and blue collar workers. London alone faced economic losses of £39.7 billion and 139,000 jobs, while the northwestern regions faced losses of £16.9 billion and 59,000 jobs and the West Midlands would fail to realize economic gains of £13 billion and 45,500 jobs over the decade leading up to 2030.[107]

In November the Oxford Economics forecasting company evaluated Huawei's contribution to the British economy in 2019 at £3.3 billion added to GDP, 51,000 jobs, and support for £1.1 billion in tax receipts for HM Exchequer—equivalent to funding the annual salaries of 30,400 teachers in UK schools. It further highlighted that the Chinese firm's contribution was 280 percent as large as it had been just four years prior, and with such a high growth rate the fallout from arbitrarily banning Huawei would be very significant. The report provided one of several major warnings from across the private sector that taking a largely ideologically motivated hard line against Huawei would seriously harm British economic interests at a time of ongoing economic decline, and in the wake of two very severe economic crises in the past twelve years.[108]

Despite widespread expectations of a severe economic fallout, the Telecommunications Bill was introduced in the British parliament on November 24 and stipulated imposition of an absolute ban on Huawei participation in 5G networks and fines on firms which failed to comply of up to £100,000 a day.[109] Huawei Vice President Victor Zhang slammed the bill stating: "It's disappointing that the Government is looking to exclude Huawei from the 5G roll out. This decision is politically-motivated and not based on a fair evaluation of the risks." He warned that the bill would leave Britain in the "digital slow lane and put at risk the government's levelling up agenda."[110] While *Time* among others referred to London's decision as "bowing to US" pressure,[111] Britain's former business and industry minister Sir Vince Cable would later confirm that after multiple briefings by UK intelligence and security services it was clear to him that the ban "had nothing to do with national security." According to Cable, Britain banned Huawei only "because the Americans told us we should do it."[112]

On December 3, 2020, an article in Chinese state media outlet the *Global Times* by British China expert and Oxford graduate Tom Fowdy claimed that

by arbitrarily targeting Huawei, the British Prime Minister Boris Johnson had "abandoned his electoral manifesto pledge to 'give all homes superfast broadband by 2025.'" It highlighted that bans on Huawei were accompanied by deep cuts to government investment in telecommunications infrastructure from £5 billion to just £1.2 billion, noting:

> The British public is now paying for Johnson's Huawei U-turn. He knew that excluding the company would narrow the UK telecommunications market, drive up infrastructure costs and, as widely warned, put Britain in the digital slow lane . . . Now, as the UK faces severe economic depletion, a record GDP decline and a record spending deficit, the government is wasting money by not upgrading its infrastructure yet removing Huawei . . . Without Huawei, the £5 billion allocated to broadband rollout in a five-year time scale is no longer sufficient. First, resources have to be allocated to replace Huawei. Second, the market is now narrower and more expensive. Therefore, the government has simply decided to cut its losses and scrap the pledge altogether.[113]

The British expert lamented that his government was "simultaneously burning Britain's bridges with its largest trade and investment partners while the economy shrinks by historic proportions," and that "taxpayer money now has to be allocated to chasing out Huawei while the government freezes public sector pay."[114]

STOPPING HUAWEI: THE STRUGGLE FOR EUROPE

In continental Europe the US campaign for a total ban on Huawei received mixed responses, with many Eastern European states proving more receptive while those which were geopolitically less closely aligned with Washington such as Belarus,[115] Serbia[116] and Hungary[117] were among the most reluctant. Huawei had been particularly popular in Europe for its distinct technological advantage in 5G over its rivals, and by 2019 over half of the telecoms giant's overseas 5G contracts were on the continent.[118] Huawei had also invested billions of dollars in Europe, from testing facilities in Bonn and Brussels opened in November 2018[119] and March 2019[120] to a research center in Leuven.[121]

The *Washington Post* reported in the first week of March 2019 that "A US campaign to dissuade other countries from using Huawei equipment in their next-generation 5G networks is facing a chilly reception among European allies." It highlighted that America's partners were skeptical of Washington's claims that the Chinese telecoms giant posed an uncontainable risk to security and warranted a blanket ban. While Trump administration officials, from the State, Commerce and Defense departments and from the Federal

Communications Commission had all made cases to European partners for a very hard line against Huawei, the *Post* cited the softer line from President Trump himself as one factor which may have led other states not to quickly yield to American pressure.[122] The article was published less than three weeks before the EU published 5G recommendations for member states which were widely criticized in the US for failing to ban and taking a relatively soft line on Chinese telecoms companies.[123]

The *Post* highlighted "a growing sense in Europe that Trump's 'America First' policies mean that what Washington calls security threats are actually trade threats"—that claims Huawei threatened the Western world were a pretext to shut out superior non-Western competition as a form of protectionism. President Trump notably strengthened these widespread suspicions in February 2019, implying that the US relied on "blocking out currently more advanced technologies" in 5G rather than trying to "win through competition."[124] Trump stated in May "that Huawei even would be included in some kind of a trade deal," which was seen to indicate that presenting Huawei as a security threat was a pretext for measures to strengthen the US economic position relative to China. As analysts at *The Verge* noted regarding claims that the firm was at once a major security threat, and at the same time could see measures against it softened under a trade deal: "These two claims are incompatible—or to be more precise, they only make sense if the security threat is a bluff. You can't negotiate away a security threat as part of a trade deal." They instead highlighted the strong possibility that "Huawei wasn't really a security threat, and Trump just used that as an excuse to escalate the trade war."[125]

Claims to similar effect[126] were widespread among analysts in the Western world and beyond, with Professor Clive Williams from the Australian National University's Centre for Military and Security Law stressing in January the lack of any evidence of Huawei conducting espionage. Regarding the motivation for the American-led campaign against the firm he stated: "Much of the security concern about Huawei is driven by rival US companies and their senior employees who have worked in the US intelligence community. Huawei is ahead of the field in 5G research so it could be an uncheckable way of reining it in and limiting its market share."[127] India's *Asian Affairs* magazine noted four months later a significantly possibility that Huawei was "just a victim of American jealousy." Regarding the reason why the Chinese firm was targeted it stated: "with success comes a backlash—especially from the US."[128] Fellow at the University College London Institute of Innovation and Public Purpose and economics editor at *OpenDemocracy*, Laurie Macfarlane, observed:

> Beneath the rhetoric about national security lies a deeper concern: that China's economic model may have the potential to rival the productive power of liberal capitalism—and threaten the technological supremacy that has long underpinned US hegemony thanks to its world-leading university, military and tech sectors . . . For all the rhetoric about a trade war, rising tensions between the US and China have never really been about trade. From the beginning, the US has been concerned with preventing China's rise as a rival technological power. In the case of Huawei, the Trump administration's goal is clear: to crush one of the first Chinese tech companies to become globally competitive, and prevent it from gaining a dominant position in a key infrastructure of the future.[129]

At the Mobile World Congress in Barcelona in February 2019, US Assistant Secretary of State for Cyber Policy Robert Strayer followed the general trend for US officials to argue for a hard line against Huawei in strongly ideological terms. He called for the telecoms giant to be banned on the basis that China, an "authoritarian regime" in his words, did not have a Western-style liberal democratic political system.[130] Huawei's rotating chairman Guo Ping, who also attended, slammed American calls for arbitrary action and highlighted that no evidence had ever been presented of Huawei planting backdoors in its systems or posing any kind of security risk. "The US security accusation on our 5G has no evidence—nothing. The irony is that the US cloud act . . . allowed their entities to access data across borders," he stated, retorting that anyone concerned about government espionage "can go ask Edward Snowden."[131] Guo's assertion was supported[132] by the fact that there had never been a major cyber security incident involving Huawei—with the exception of the times Huawei was itself targeted by American intelligence as Snowden had revealed.

Much like in the third world, the lack of evidence to support claims of a Huawei threat led the US to resort to threatening its European allies with reprisals if they refused to comply with its demands. In Germany, US Ambassador Richard Grenell warned on March 7, 2019, that America would limit intelligence sharing unless Berlin banned Chinese firms from its 5G networks.[133] With Germany's Federal Office for Information Security finding no evidence of any security threat or malpractice from Huawei,[134] American threats initially did not seem to have an effect on Berlin's position. Although Chancellor Angela Merkel was urged by her foreign and interior ministers to impose a ban on Chinese participation, she stated that she opposed singling out a company "simply because it is from a certain country."[135]

Debate in Germany intensified and remained heated for almost two years, with the ruling Christian Democratic Union mirroring the US' own ideological position in a statement on November 23rd that: "Only those suppliers can be trustworthy that are not under the influence of undemocratic states."

With China widely deemed 'undemocratic' in the Western world due to its non-Westernized political system, the message was clear even though the country was not mentioned by name. With all major German mobile operators already using Huawei, several of the country's leading firms warned that a ban on Chinese telecoms equipment would significantly delay the rollout of 5G in the country.[136] For their existing 4G networks, Huawei components made up around 65 percent of the infrastructure used by Deutsche Telekom, 55 percent by Vodafone and 50 percent by Telefónica.[137]

At the end of 2020 the German government remained adamant that it would not ban individual suppliers, but created a two part assessment mechanism with which relevant ministries in Berlin would decide whether to allow a company to take part in the country's 5G networks. This meant that even if Huawei passed all technical and security tests, a ministry could later announce a political reservation—which was hailed as a step in the right direction by the US State Department.[138] The law notably only allowed for the exclusion of a vendor, however, if all involved authorities unanimously decided to enact a ban, which made it more difficult to block Huawei. This was described by Western analysts as a "nod to Huawei," a "conditional green light" for Huawei, and a "setback for the outgoing US administration."[139] The *Financial Times* referred to it as a "high hurdle for Huawei"—but still far short of a decisive ban.[140]

Analysts at the *Asia Times* described penetration of the German market as allowing Huawei to "hit 5G critical mass,"[141] with its potential success in Europe's largest economy likely to set a precedent for others on the continent and beyond to reject US pressure. As debate over Huawei continued, domestic telecoms companies had over two years bet strongly against the possibility of a Huawei ban and began incorporating the firm's equipment into their 5G networks. This posed a risk that they would be forced to remove it at their own expense if the government ruled in favor of banning Huawei, but it also placed more pressure on Berlin not to impose a ban by placing the momentum behind Huawei and increasing the economic losses that a ban would incur.[142] Europe's largest telecoms provider Deutsch Telecom in particular was expected to make very significant losses if forced to cut ties to Huawei. The two firms agreed in mid-2019 on plans for a fast 5G rollout which would see Huawei provide preferential access to its equipment stocks and cover the costs of any potential disruption or delay caused by American measures against it. The German state notably held a 14.5 percent stake in Deutsch Telecom, with *Politico* referring to Huawei's deal to supply it as "a near-guarantee that it [Huawei] would hold a strong position on the European market for years to come."[143] By mid-June 2020 Deutsch Telecom had already rolled out 5G to more than 16 million people across some 12,000 antennas around Germany using equipment from both Huawei and Ericsson.[144]

Several politicians criticized network operators for starting the 5G expansion with Huawei before the decision on whether to ban it was made. As was seen across the world, the business community and private sector largely aligned with Huawei and favored continued normalcy in relations with China, while ideological arguments advocated a very costly purge of the world's most advanced 5G technologies.[145]

Beyond the immediate detrimental effects blocking Chinese telecoms companies would have on the German telecoms industry, Berlin could not afford to take a harder line against China due to potentially much wider repercussions for its economy. In 2019 alone Germany had exported nearly €100 billion ($112 billion) worth of goods to China, which accounted for more than half of the value of all European Union exports to the country.[146] The Chinese market was the primary driver for growth in German exports, particularly after 2020 when its demand proved much more resilient than that of the US, and China was projected to become the largest importer of German goods.[147] This and the even greater volume of Chinese exports to Germany made China the country's largest trading partner, meaning many in Berlin felt they could not afford to alienate Beijing despite considerable American pressure.[148] Combined with pressure from private sector interests and the massive immediate costs that compliance with US demands would incur for its telecoms sector, these factors made it favorable for the German government to stall any decisive action on Huawei particularly when dealing with the Trump administration. It would in the meantime continue to turn a blind eye to its telecoms sector working with Huawei on 5G. With the less confrontational administration of Angela Merkel losing power in 2021, the nature of its successor's orientation was expected to play a central role in determining Germany's future with Huawei.[149]

While Germany remained divided on Huawei, but was leaning toward a softer line, Washington was having more success elsewhere in the Western world. By the end of 2020 Australia, Britain, Estonia, Poland and Sweden had banned Huawei from operating, although other than Japan no non-Western country had taken steps toward doing so. Where these had banned Huawei outright, other Western countries such as Italy instituted bans in all but name, avoiding confrontation with China by adding bureaucratic and financial hurdles to incentivize firms not to work with the Chinese company and shutting it out of certain important tenders.[150] Other cases included Albania, which had withdrawn from a joint Vodafone-Huawei project under significant overt US pressure,[151] and Canada and Lithuania which were strongly considering total bans.

In late 2020 the Trump administration signed several bilateral declarations with countries in Central and Eastern Europe in quick succession aimed at denying Huawei the ability to compete for contracts for 5G

telecommunications infrastructure. In the penultimate week of October alone agreements were signed with Slovakia, North Macedonia, Kosovo, and Bulgaria. That month *Foreign Policy* referred to Washington as "Turning More Countries in Europe Against Huawei." It highlighted the case of Slovakia in particular where, after having previously maintained relatively positive relations with China and Russia by Western standards, a new administration took a harder line against both countries as well as against Huawei as a means to cement ties with the US. The report, among many others, made clear that such actions were more than anything motivated by political factors which were not related to any security threat, and which allowed Huawei's overwhelming qualitative and price advantages to be ignored.[152]

The Swedish ban in October 2020, which included the removal of existing Huawei equipment from telecoms networks, was the last of the year and was considered by analysts to be "unusually forceful."[153] The Chinese Foreign Ministry responded by stressing that the country "deplores Sweden's decision," accusing the European state of "using national security as a pretext to slander Chinese companies, openly oppress Chinese telecom companies, and politicize normal economic cooperation."[154] Sweden was one of the leading European countries by measure of Sinophobia and anti-Chinese sentiments, with 70 percent of Swedes holding overall negative views of the East Asian country in 2019. This spiked at 85 percent in 2020 due primarily to widespread portrayals of the COVID-19 pandemic as having been caused by China.[155] The Huawei ban came amid growing reports of extreme racism in Sweden particularly targeting Chinese and East Asians, as reported by the UN among others, which included leniency toward neo-Nazi organizations, mistreatment of Chinese tourists by police, and publication of bigoted media content targeting Chinese people.[156]

Following an appeal by Huawei against the ban, which led to a Swedish court suspending parts of its decision to exclude it from 5G networks, the Scandinavian country took more radical action in November 2020 and entirely halted its 5G spectrum auctions for all offers. This was seen by many analysts as part of a policy to block Huawei at all costs even if legal avenues for doing so were removed and even if it meant suspending its entire 5G tender.[157] Moves to block Huawei were notably criticized by the chief executive of Swedish telecoms company Ericsson, Borje Ekholm, who stated on November 17 in an interview with the *Financial Times* that it went against the principle of free trade and would delay 5G rollouts in both Sweden and the European Union.[158]

In the first week of January the following year Ekholm warned the Swedish Minister of Commerce Anna Hallberg that "if the ban on Huawei still exists, Ericsson can leave Sweden." Analysts interpreted this warning as a response to concerns that, with Ericsson having a strong presence in China and a ten

percent market share in fixed networks, the firm could face similar bans from the Chinese government if it did not distance itself from Stockholm's position.[159] A 10 percent market share in China's 5G equipment market, which was by some estimates ten times larger than that in the US, was extremely important to Ericsson.[160] A subsequent risk assessment report by Ericsson in May largely confirmed this speculation, with the firm perceiving its future to be seriously threatened as a consequence of Stockholm's moves against Huawei.[161] Ekholm subsequently moved to take the Swedish government to court for its actions against Huawei, although he faced considerable setbacks stating: "Although we have talked with several Swedish law firms, no one is willing to help Huawei. There are many cowards here."[162] Eckholm's efforts proved insufficient in light of the severity of Swedish government actions, with Ericsson failing to win new infrastructure contracts in China in 2021 and seeing revenues contract sharply which was widely interpreted as retaliation for Sweden banning Huawei from its own contracts.[163]

Closely coinciding with the announcement of Sweden's blanket ban on Huawei a leading executive from Deutsche Telekom, the head of spectrum policy and projects Tony Lavender, warned that such arbitrary government measures were serving to isolate Europe from the "wider scope" of developments in the global telecoms industry.[164] A report from MTN Consulting the previous month had reached similar conclusions, attributing blame to "muddled" network investments by several governments and arbitrary actions against Huawei. Resulting problems, it noted, were compounded by the fallout from the COVID-19 crisis.[165]

The success of the campaign against Huawei within the Western world depended largely on momentum. If countries openly defied US pressure to take action against Chinese telecoms firms then it was imperative for Washington and its partners to quickly penalize them, lest their precedents diminish momentum for further bans. As US analyst Meaghan Tobin was one of many to observe in early 2019: "America may back down on its threats if enough nations call its bluff, especially in the face of what are seen by many as unreasonable demands."[166] Conversely the more countries implemented bans the more pressure would increase on those which had not yet done so. As *Reuters* observed on July 14, 2020, the day Prime Minister Boris Johnson announced the ban on Huawei:

> Britain's decision to ban China's Huawei from its 5G network increases further pressure on EU countries to impose stricter limits on the world's largest telecoms equipment maker just as the company expands its footprint across Europe . . . Europe now finds itself front and center of the US drive to uproot Huawei from next-generation mobile networks. Robert O'Brien, the US national security adviser, arrived in Paris on Monday for three days of talks with his counterparts

> from France, Germany, Italy and Britain. Washington has made clear that 5G networks are on the agenda. [167]

Throughout much of the world countries were faced with a stark choice. Work with the more advanced and cost-effective vendors and risk hostile actions by the US, or make serious sacrifices to economic well-being and infrastructure. The latter, US officials repeatedly indicated in strongly ideological terms, was a sign of loyalty to the geopolitical interests of the collective Western world and to Western ideology.

Europe remained in a poor position to ban Chinese firms from its 5G networks, with an EU-wide ban estimated to cost €55 billion ($62 billion) and even when excluding the significant costs that delays rolling out the new technology could have for European firms' competitiveness. The estimate was released in 2019 by the GSM Association, a London based telecoms industry organization, with Huawei and ZTE between them already holding a 40 percent market share in the EU at the time. GSM's report projected that arbitrarily banning Chinese firms would lead to "higher input costs following significant loss of competition in the mobile equipment market" and "would widen the gap in 5G penetration between the EU and the US by more than 15 percentage points by 2025."[168] Such concerns were shared by political leaders across the continent, with *The Economist* noting in July 2019 regarding the ongoing debate over Huawei and ZTE that "European politicians fear falling further behind if they delay 5G and the various wonders it is held to enable."[169] In Europe the average revenue per mobile-phone user was less than €15 ($17) a month—less than half what the average American user paid. Providing an indicator of the price difference, the cheapest unlimited-data plan in America cost €74 a month, while in Germany and Britain it was only €40 and €22. This gave European telecoms companies far less room to maneuver in terms of the cost effectiveness of their investments.[170]

The loss of often ludicrous Western markets with particularly high internet consumption had the potential to deal a major blow to Huawei's prospective growth. Nevertheless, the campaign against Huawei also highlighted the extent to which the US had seen its ability to influence the world to fall in line against its adversaries diminish. A large part of this was due to China having long since surpassed the US as the world's largest trading nation, with the large majority of countries prizing trade relations with China much more than those with America. While Huawei's rise threatened Western dominance of a key area of global high tech, the pretext of a security threat for singling the firm out as a target was far from persuasive even for America's closest allies. Indeed, considering the known practices of Western intelligence agencies and the tech giants that worked with them, as revealed by the Snowden files among other sources, Huawei could be seen as a much safer option.[171] In

part as a result, US efforts to deny Huawei access to global markets by presenting it as a security threat were having an underwhelming impact beyond the Western world, and even in Europe faced an unexpectedly high level of resistance.

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Chapter 7

Huawei's Future and Security Challenges

ADAPTING TO SURVIVE THE TECH WAR

Despite a ban on operations in the US, and a range of measures taken to hinder it across much of the Western world, Huawei saw a tremendous 30 percent growth in revenue in the first half of 2019. This represented a marked improvement over performance the previous year,[1] with executives reportedly expressing their relief to staff that the fallout from the firm's targeting by Washington had not been worse.[2] Further surprising Western analysts, and benefitting from the Chinese economy's relative resilience to the COVID-19 pandemic, Huawei maintained revenue growth in the first half of 2020.[3] The *Financial Times* accordingly titled a July article "China tech juggernaut steams ahead," highlighted the extent to which the country's tech sector with Huawei at the forefront was maintaining a formidable growth rate despite all manner of obstacles.[4] In April *The Economist* had somewhat begrudgingly similarly noted in the title of a prominent article: "Huawei reports resilient results: Neither American sanctions nor COVID-19 seem able to slow its rise much."[55]The firm went on to make record profits in 2021 with a 75.9 percent surge over the previous year and comfortable leadership with 28.7 of the global telecommunications market. This was achieved despite setbacks resulting from targeting by the United States, with innovation and a rebalancing to focus on business areas less vulnerable to Western sanctions largely responsible for the firm's success.[6]

Although Huawei had overall proven resilient particularly in its telecoms infrastructure business,[7] by the end of 2020 its smartphone business which still relied heavily on semiconductors produced with American inputs was evidently struggling. The firm reported revenues in 2020 just 3.8 percent

higher than 2019, the slowest growth in over a decade, with smartphone revenues contracting sharply. Deputy Chairman Eric Xu in early 2021 referred to the possibility of a loosening of American restrictions as "illusion or fantasy,"[8] announcing that Huawei was planning its future based on their continuation. A notable step taken to adapt was the sale of its Honor smartphone brand, announced in November 2020, to the Shenzhen Zhixin New Information Technology consortium. The sale's value was unconfirmed but quoted from $15.1 billion to $40 billion.[9] Honor was a budget brand which, according to market research firms IDC and Strategy Analytics, had comprised between 28 and 38 percent of Huawei's total smartphone shipments in the first half of 2020.[10] The divestment spared Honor from the American restrictions and allowed it to acquire semiconductors and use Google services. Honor subsequently released competitive new 5G smartphones and moved away from a focus purely on budget phones and toward higher end handsets.[11] It further reportedly planned to open new stores and to boost output by 40 percent in 2021 to reach 100 million handsets.[12]

The *Shenzhen Special Zone Daily* reported that the sale "is the best solution to protect the interests of Honor's consumers, channel sellers, suppliers, partners and employees. More importantly, this acquisition is a multi-win move for the industry." Industry experts widely made similar assessments.[13] Had Huawei not sold Honor the brand would likely have lost considerable value and market share due to insufficient semiconductor supplies. The sale thus appeared to be damage control in response to American attacks, with unverified reports in January 2020 indicating that other parts of Huawei's smartphone business could similarly be sold to other Chinese firms with decisions still pending. This was denied by Huawei and appeared unlikely, but did present a last resort to reduce pressure on the firm and minimize overall damage to Chinese leadership in the global smartphone market.[14]

In the field of smartphones Huawei's response focused on the long term,[15] and preceding the implementation of the chip ban in September 2020 the firm had prepared for possible US attacks by increasing the size of its semiconductor inventories by 73.4 percent annually.[16] Stocks had also been built of passive components and optical parts in areas that were identified as being at higher risk from being targeted by the US.[17] The limited number of chips[18] available in Huawei's inventory, which although substantial was not being replenished after 2020, seriously restricted its smartphone business including even its high-end flagship models that were produced in smaller numbers. As a result a number of franchise retailers in China closed their stores and the firm yielded much of its market to rival domestic brands such as Oppo, Vivo and Xiaomi.[19] Xiaomi's share was growing particularly quickly even before September 2020, and in July 2021 it overtook Apple to become the world's second largest smartphone vendor.[20] Where one Chinese smartphone brand

fell under American attacks, there were several others to quickly occupy its market share.

In January 2021 Oppo was reported to have overtaken Huawei in smartphone sales in China and gained 21 percent of the market, closely followed by Vivo at 20 percent. The divestment of Honor, which had previously been counted as part of Huawei sales, was the primary cause of lost market share but not the only one, with sales having declined sharply in the final quarter of 2020 due to constraints on chip supplies.[21] Looking beyond China Huawei was predicted at the beginning of 2021 to fall to seventh place in global sales behind Samsung, Apple and the four Chinese brands Xiaomi, Oppo, Vivo and Transsion.[22] Despite Huawei's fall, the position of Chinese handsets internationally had consolidated well and their overall market share had increased considerably, with consumers on the whole turning from Huawei to rival Chinese brands rather than to Apple or other East Asian competitors. Indeed, in spite of a sharp decline in production from Huawei, Chinese smartphone brands were predicted at the beginning of 2021 to capture around 60 percent of the global 5G smartphone market that year.[23] While Huawei saw its global smartphone shipments fall 41 percent year-on-year in the fourth quarter of 2020, and in Europe saw a sharper fall of 62 percent, Xiaomi, Oppo and Vivo all saw double-digit shipment growth.[24] Huawei subsequently saw a 50 percent year-on-year decline in smartphone sales in China in the first quarter of 2021, shipping just 13.5 million phones while Vivo, Oppo and Xiaomi maintained high doubledigit growth.[25] Its share of the global smartphone market fell by 81.6 percent that year, and having held 15 percent of the world market in 2020 it held just 3 percent in 2021.[26]

Moves by a number of Chinese smartphone producers to focus more on higher end handsets than they had previously was described by analysts in early 2021 as an attempt to "fill void left by Huawei."[27] Following the launch of the new Mi 11 Ultra high-end phone, Xiaomi CEO Lei Jun stated to this effect in March: "Early last year, we started to move into the high-range market. I think we have found a foothold in the high-range market."[28] Rival Chinese smartphone manufacturers, alongside domestic semiconductor producers, had been predicted to be the prime beneficiaries when Washington's escalation against Huawei was announced in August 2020,[29] although it remained uncertain whether they too would later be similarly targeted by the US in response to their successes. Washington notably designated Xiaomi a "Communist Chinese military company" in January 2021 and sought to impose restrictions on its activities,[30] but this was blocked in March under a new administration in Washington after the firm filed a lawsuit challenging the designation.[31]

Xiaomi's fiercest competition came from within China not only in domestic markets but also overseas where Chinese brands had escalated investments

in marketing and distribution in the wake of Huawei's supply shortages. Oppo for example, having made its name by selling low-cost smartphones, launched the high-end Find X3 Pro to compete with Xiaomi's Mi 11 Ultra and push into markets that would have been dominated by Huawei's Mate 40 Pro and P 50 Pro handsets.[32]

Huawei's falling smartphone sales did not reflect the overall state of the firm, but rather the primary area of decline due to an outstanding weakness in supply chain security which the US had effectively exploited. In 5G, for example, Huawei was still the world's leader by a very considerable margin in both technology and market share despite American lobbying efforts and even threats targeting its potential clients across the world. Huawei's smartphone business was expected in the medium term to focus more heavily on high-end luxury handsets, which allowed it to reap greater profits while expending a smaller number of its limited chips, alhtough the overall number of handsets produced in 2021 would be less than half of 2020.

In February 2021 Huawei launched one of the most expensive flagship handsets in the history of the industry—the Mate X2 foldable 5G phone with a price starting at 17,999 yuan ($2,785).[33] Foldable phones were particularly expensive from all suppliers and had been pioneered by Huawei. The Mate X2 used the same Kirin 9000 chips as the Mate 40, with the chips also expected to be used in future P 50 and Mate 50 high-end models which were reportedly prioritized over the older Mate 40 for access to the limited stocks.[34] With demand for the Mate X2 being far lower than that for the Mate 40 as a niche luxury phone, investing in continuing the series would not seriously deplete Huawei's chip inventory while yielding a much greater revenue per chip than using the chips in the Mate 40. The new phone was one of the first to launch using Huawei's self-developed Hongmeng operating system. Continuing to improve its high-end luxury smartphone designs ensured Huawei retained both the skillset needed to compete at the cutting edge and the reputation for doing so. If the high-end lines could continue to match or surpass competitors in terms of performance, re-establishing larger scale production of these and lower end models would be a much simpler task once issues with chip supplies were overcome. Considering the scale of investment in developing its own chipmaking capability, and broader Chinese efforts to secure semiconductor supply chains, the sudden but severe shortage of chips appeared likely to be a temporary setback rather than a permanent end for Huawei's smartphone business.

Washington's move to block semiconductor producers around the world from using US software to supply Huawei was a major blow to producers, which were primarily located in American strategic partners such as Japan, South Korea and Taiwan as well as in the US itself. This was considerably more serious than the aforementioned prior damage done to US industry

in 2019 by placing Huawei on the Entity List and restricting supplies to it. John Neuffer, the president and CEO of the US Semiconductor Industry Association which represented 95 percent of the domestic industry, was among many to argue that Washington's harsher restrictions imposed in 2020 were counterproductive and excessively harmful to American producers. "Sales of nonsensitive, commercial products to China drive semiconductor research and innovation here in the US, which is critical to America's economic strength and national security," he stated, warning that "these broad restrictions on commercial chip sales will bring significant disruption to the US semiconductor industry."[35]

Corroborating Neuffer's claims the world's second largest consulting firm the Boston Consulting Group reported that restrictions could cost US firms 37 percent of their annual sales in electronics and software. It cited medium revenue decline for top US semiconductor makers of between 4 and 9 percent in each of the three quarters following the ban on supplying Huawei in May 2019.[36]Semiconductors production across America had plummeted, with analysts from Morgan Stanley highlighting "very high inventories on semiconductor balance sheets," "weak end demand in nearly every semiconductor end market, [and] a once in a generation magnitude of memory oversupply" as a result of the restrictions on supplying Huawei.[37]

Broader restrictions beyond the chip industry took a further toll on Huawei's suppliers in the US and US-aligned countries, with California-based Qualcomm having lobbied the government to revoke restrictions on component sales. It reported that these restrictions had cost it a market worth as much as $8 billion annually.[38] Huawei had been a major client for optical and analogue components from the US with NeoPhotonics, Lumentum, Inphi, Qorvo, II-VI, and Finisar relying on supplying the Chinese firm for 49 percent, 18 percent, 14 percent, 13 percent, 9 percent and 8 percent of their respective revenues. All were hit very hard by the ban on supplying Huawei.[39] Should efforts against China's tech sector further escalate to target more firms, US producers were placed at serious risk with Qualcomm, Micron Technology, Qorvo, Broadcom, and Texas Instruments each earning more than 40 percent of revenues from China and Intel and Nvidia more than 20 percent.[40]

Japan's Sony was a notable example of a firm in an allied country that was seriously affected by US restrictions on chip exports to Huawei, and projected a 140 billion yen ($1.26 billion) decline in profits for its semiconductor arm for fiscal year 2021 as a result. This was its second year of declining profits as a direct result of Washington's policies.[41] Japanese firms had supplied parts worth around $10.4 billion to Huawei in 2019, with American restrictions imposed in 2020 forcing Sony to trim its capital spending plan for three years and alter the fields it planned to invest in. Among the other Japanese firms seriously affected were Renesas Electronics, which had been one of the

Huawei's leading suppliers for semiconductors for 5G network base stations, as well as Kioxia and Mitsubishi Electric which were forced to suspend shipments of flash memory.[42]

South Korea's top chipmakers Samsung Electronics and SK Hynix both lost a leading client in Huawei due to Washington's policies. The Chinese mainland market, of which Huawei made up a significant portion, accounted for 41 percent of all South Korean chip exports in the first seven months of 2020—valued at $22.49 billion. The Hong Kong market came second at 20.8 percent, or $11.38 billion, meaning China excluding Taiwan accounted for over 60 percent of South Korean chip exports. The risk of further American attacks to target other Chinese tech firms alongside Huawei were thus potentially devastating for the Korean chip industry, with restrictions on Huawei alone expected to cost Korean chipmakers 10 trillion won ($8.45 billion) in lost exports in the first year and tens of billions more over the following half decade.[43]

The massive losses incurred by tech firms and particularly by semiconductor producers provided a strong impetus for firms in Japan, South Korea, Taiwan and the US to lobby hard against further escalation by Washington. It also further strengthened the incentive to develop software for chip fabrication which was not subject to US laws. This would not only allow firms to resume supplying Huawei, but also secure them against further blows to their sales from any new legislation in Washington. Indeed, in December 2021 the first indications that Taiwanese semiconductor firms could pursue creation of a supply chain free from US inputs to this end emerged.[44] Speaking anonymously, a senior executive from a Chinese technology company warned that there were serious concerns among chipmakers that the US would seek to impose similar bans on selling chips to other Chinese firms. "If Huawei is done, who will be next? Dozens of Chinese tech companies that have already been put on the US government blacklist? Or any non-US technology pioneers?" He highlighted that a move to target more major Chinese tech firms would be intolerable for major chip producers.[45] The fact that Washington was offering some American suppliers exemptions to supply Huawei with older 4G chips, while imposing a blanket ban on all foreign chip suppliers, was seen as a blatant attempt to increase US semiconductor market share while arbitrarily disadvantaging non-US suppliers. This only further strengthened the incentive for non-US producers to develop production processes without American inputs.[46]

Overall market and technology trends continued to strongly favor Huawei and the wider Chinese telecoms industry, with the US-led campaign slowing the tide toward their growing primacy but ultimately falling far short of reversing it in both wireless network infrastructure and in smartphones. Former Senior Director for Cyber Operations on the US National Security

Council Staff Thomas Donahue thus underlined in a paper for *Military Cyber Affairs* that sales restrictions were attempts to create time and space for US industry to innovate and be competitive in the tech and information sectors. However "it would not be sufficient to overcome a US deficit in the marketplace for high-end telecommunications integration." He instead advocated "leadership from the US Government along with sustained focus and resources," a field where he said Washington could learn from Beijing, combined with support from "western-oriented" strategic partners to push back against Chinese dominance.[47]

The emergence of a peer level competitor to Huawei of Western origin, or signs of the beginnings of US government leadership as Donahue and others had called for, were not forthcoming. Indeed, as the more efficient producer Huawei had the power of market forces behind it from the outset leading to staunch opposition against the politically motivated and ideologically premised campaign against the firm from private sector interests in the West and across the world. Even preceding bans on supplying Huawei, moves by the US government in 2018 to stop the use of Huawei or ZTE equipment in domestic infrastructure had already been met with strong private sector opposition domestically. This mostly came from the wireless and wireline industry associations which deplored the idea that equipment which was at once the most advanced and the most cost effective should be banned. Associations in the wireless and broadband industries including Competitive Carriers Association (CCA), the Cellular Telecommunications Industry Association, and the Independent Telephone & Telecommunications Alliance, a well as the rural broadband association NTCA, all strongly protested. CCA president and CEO Steven K. Berry, for one, warned that restrictions: "will devastate impacted rural carriers, which execute the FCC's mission to expand high-quality access to telecommunications and information services . . . It would especially harm rural consumers, placing them at jeopardy with little to no national security benefit. The proposed rule is punitive and disproportionate to a small group of providers of service to rural America and will cause more harm than good."[48] As the scope of the campaign against Huawei expanded, so too did private sector resistance.

By strongly incentivising Huawei and its suppliers to phase US inputs out of their supply chains, American measures against the firm would have a potentially devastating impact on the domestic tech sector in the medium and long term. Still without peer in 5G, Huawei became a national champion that was much better known worldwide as a result of the attacks on it. To place Huawei's position in perspective, while the firm added 16,000 new jobs in the year 2020–21 its leading competitor Nokia in March 2021 announced that it would cut between 5,000 and 10,000 jobs over the next eighteen to

twenty-four months. This represented a significant contraction, with Nokia's workforce standing at only 90,000 at the start of 2021, and followed deep cuts of 5000 jobs in 2019 and a further 6000 in 2020. It faced a three year decline in total R&D investments with the possibility of even more cuts to the workforce having been speculated. Nokia was expected to dispose of some of its businesses through outright sales or spin-off arrangements.[49] This came despite significant benefits for Nokia's global market share in telecoms infrastructure as a result of arbitrary bans on its leading competitor Huawei.

Huawei's importance as a perceived symbol of Chinese resistance to US coercion and politically motivated impediment to free trade meant that it was expected to continue to receive considerable government backing to retain its advantages. The scale and sophistication of R&D taking place in China for potentially revolutionary technologies for the telecoms sector, many of which China was expected to emerge as world leader in, thus boded ill for Huawei's overseas competitors. Among these technologies were Quantum Computing and space-based commercial communications networks, the latter which was expected to be a central feature of sixth generation internet technologies (6G). Director of the Strategic Technologies Program at the Centre for Strategic and International Studies, James Andrew Lewis, noted to this effect as early as 2018 that while US efforts to compete with China in 5G networking had amounted to very little: "In the meantime, China is spending heavily on quantum computing (which might provide an advantage in breaking hitherto-secure encryption), quantum communications satellites (which could defeat Western efforts at collection), artificial intelligence and data analytics." The result, he predicted, was Chinese primacy in telecommunications while the US, "through overconfidence or forgetfulness," appeared not to even have a plan.[50]

In November 2018 it was revealed that China's Ministry of Industry and Information Technology had begun work on 6G with initial commercial deployments expected to begin as early as 2030.[51] The project worked toward developing communication networks with bandwidths over 1 terabit per second, or over 100–400 times the speed of 5G, with grants of hundreds of millions of dollars. 6G would build on 5G infrastructure and applications, and as a result development would need to build on a prior investment in 5G.[52] The new generation was speculated from an early stage to make use of integrated terrestrial and space-based network elements which, it was pointed out by analysts at *Military Cyber Affairs*, China would likely have a major advantage in as its ability to conduct space launches continued to grow rapidly.[53] In mid-September 2021 Huawei CEO Ren Zhengfei pledged that the firm would lead in 6G development, urging employees to "break the limits in the sky" in setting standards for the new industry much as they had done for 5G.[54] The Chinese State Council's digital economy plan, details of which emerged

in January 2022, placed a particularly strong emphasis on setting standards for 6G.[55] Reports of this emerged just days after a major breakthrough where Purple Mountain Laboratories, supported by a special government 6G project, achieved the world record by a considerable margin for 6G-level wireless transmission speeds.[56]

A 2021 survey by *Nikkei* and the Tokyo-based Cyber Creative Institute research company of around 20,000 patent applications for core 6G technologies found that China led the world with 40 percent of all patent filings.[57] *Nikkei* highlighted that the country's basic research in the field had maintained momentum despite wide ranging efforts by Washington to obstruct it, noting as an example the launch of the world's first 6G satellite the Tianyan-5 in November 2020 by the University of Electronic Science and Technology of China.[58] The satellite was designed to test a high-frequency terahertz communication payload that could send data at speeds several times faster than 5G.[59] The Japanese paper was one of many sources to predict that China would have an upper hand for setting the rules for 6G at the International Telecommunication Union when discussions surrounding the technology began in the mid-2020s.[60] Trends in the industry provided a strong basis to predict continued leadership by Chinese firms with Huawei being the prime player among them. 6G remained a major focus for Huawei despite a general shift to focus away from hardware and more on software.[61]

Huawei took the slowing of its smartphone business as an opportunity to diversify its operations, and was reported to have used the income from the divestment of Honor to invest in artificial intelligence and Cloud services in particular as new growth areas. The firm had already emerged as China's leading owner of AI intellectual property in China in 2019 with a very comprehensive set of AI products, and subsequently expanded its lead. Tencent and Baidu had come second and third place that year,[62] with Huawei and Tencent announcing plans in early 2020 to cooperate in developing a range of video game products using cloud, AI, virtual reality and augmented reality products.[63] The range of AI products covered continued to expand, and by 2021 the firm had even launched AI pig farming to compete with major challengers such as JD.com, NetEase, and Alibaba. This was a potentially lucrative field domestically, with China being home to half the world's live pigs and pork consumption continuing to rise.[64]

Huawei captured a 17.8 percent share in China's Cloud market in the fourth quarter of 2020, second only to Alibaba's 40 percent, and by the end of the first quarter of 2021 its Cloud revenue was 268 percent what it had been a year prior. China was the world's second biggest cloud market and by far the fastest growing, with the market's value rising 66 percent to $19 billion in 2020. As part of this shift in Huawei's focus the chief executive of its consumer business group Yu Chengdong, who had overseen the success of the

firm's smartphone business, was made head of the Cloud and AI business units in January 2021. This was seen as a major step to link these business units with front end services such as smartphones and personal computers.[65]

In April 2021, Huawei revealed that its Hongmeng OS had been integrated onto smart cars as one of five automated driving solutions developed by the firm. This came as part of its considerable investment in self-driving and electric-vehicle research which amounted to $1 billion in 2021 alone. These cars were being jointly developed by Huawei and Arcfox, a unit of state-owned automaker BAIC Group. The telecoms firm would only invest in developing specific technologies and solutions as opposed to a full car, unlike its rivals Xiaomi and Apple which were seeking to fully develop cars themselves.[66]

In May 2021, at its ecosystem conference in Shenzhen, Huawei unveiled new innovation plans to build its independent ecosystems and further step up 'self-rescue efforts.' This included upgrading six self-developed digital technology ecosystems—Kunpeng, Ascend, Huawei Mobile Services, Hongmeng OS, Huawei Cloud and Mobile Data Center—which were all much less vulnerable areas than smartphones. With smartphone production volumes having declined considerably, developing core independent technical frameworks and ecosystems provided Huawei with an effective means of both compensating for its losses and achieving greater self-reliance. Hongmeng was expected to be integrated onto at least 300 million devices by the end of the year, a large portion of which were not smartphones, and with around 500 million Huawei phones in use globally there was significant room for more widespread adoption over time. The focus of Hongmeng OS was expected to gradually shift to other devices such as smart household appliances and smart watches as part of what was increasingly referred to as the Internet of Things to network all devices.[67] The launch of Hongmeng OS 2.0 in June stimulated further expansion of its usage.[68]

Also in May Huawei confirmed that work had begun on its latest 3 nanometer semiconducor chip the Kirin 9010. This investment demonstrated considerable faith that opportunities would emerge to fabricate such chips in future either through a lifting of US restrictions or through development of an independent fabrication process free from American inputs.[69] No intention was expressed to restructure chip design subsidiary HiSilicon despite the fact it has more than 7,000 workers on Huawei's payroll and was expected to go years without contributing to earnings, indicating expectations of a return to normality and a regaining of the ability to fabricate its own custom designed 5G chips.[70]

Tech Giants and Espionage

US efforts to target Huawei from 2018 were a critical part of the broader tech war on China, and for pretext relied on accusations that the Chinese firm served as a trojan horse to provide Chinese intelligence with access to global communications. Although evidence was considered wholly underwhelming even by US allies, and the NSA's deep penetration of Huawei had confirmed it had no unusual ties to the Chinese defense establishment and was not involved in espionage, these allegations raised questions regarding how Western dominance of key global infrastructure benefited the West's own surveillance efforts. It also raised several questions regarding the kinds of relationships US and Western tech firms had with their own countries' intelligence services, militaries and foreign policy agendas, and whether accusations made could be a case of projecting common Western practices onto the Chinese firm.

Reports of the intrusive and often illegal activities of Western intelligence agencies, and of tech giants' collaboration with them, were manyfold particularly following the Obama administration's inauguration in 2009. Any one of these reports was more serious than anything Huawei was even accused of perpetrating. One example was a technique used across the world by the NSA called "method interdiction" under which the American agency intercepted packages en-route to their recipients, installed malware or backdoor-enabling hardware, and then returned the package on its way to the customer.[71] It also hacked the data centers of Yahoo and Google, paid security software provider RSA to put encryption backdoor in its products,[72] and conducted widespread industrial espionage targeting American technological rivals including multiple firms in Germany and China. This included theft of technologies which were not directly related to national security, but the appropriation of which was seen to further US national interests.[73] What was particularly notable about how the NSA operated was that American tech companies such as Microsoft, Google, Yahoo, Facebook, PalTalk, YouTube, Skype, AOL and Apple were all made to work to facilitate its surveillance efforts, and were forced by gag orders not to disclose this to the public.[74] While the US pushed for a global ban on Huawei based on unevidenced allegations, each of these American firms was found to be doing precisely what Huawei was accused of—although no other country sought to use this as a pretext to press for a global ban on Apple, Microsoft or others.

While only a small minority of the intrusive surveillance operations by the US and its allies were ever discovered, the known cases were significant. They ranged from the NSA's tapping of German Chancellor Angela's Merkel's phone[75] to the British GCHQ's tapping of network cables carrying phone calls and internet traffic to effectively spy on the whole world's

communications.[76] In 2013 NSA whistleblower Edward Snowden revealed that China's government and population were extensively targeted for highly intrusive surveillance by US intelligence. This included hacking into Chinese mobile phone companies to access millions of private text messages,[77] attacking the network backbones of the country's top ranked university Tsinghua,[78] and hacking the headquarters of Pacnet which owned one of East Asia's most extensive fiber-optic submarine cable networks,[79] among multiple other serious offenses. Pancet's network connected the Chinese mainland, Taiwan, Hong Kong, South Korea, Japan, the Philippines and Singapore with over 46,000 kilometers of cables, and compromising these systems provided intelligence on all of these countries and territories.[80] Efforts to target Tsinghua were described as "intensive and concerted," and in just one day in January at least sixty-three computers and servers at the university were hacked by the NSA. Other universities across the mainland and Hong Kong were also targeted.[81]

The Snowden revelations in 2013 were far from isolated, with leaked information on how US intelligence agencies were operating showing very similar kinds of highly intrusive operations being carried out unconstrained by either laws or national borders. Documents published by Wikileaks in 2017,[82] which were reportedly leaked by CIA coder Joshua A. Schulte, showed that Chinese aviation, energy, internet and even government sectors had been targeted and hacked into by US government agencies for over a decade. An investigation Beijing-based cybersecurity firm Qihoo 360 found that the CIA was largely responsible, with multiple key sectors targeted by "CIA-exclusive cyber weapons" such as Fluxwire and Grasshopper frameworks which the agency used to build malware. Chinese cybersecurity experts were highly concerned in the aftermath that large amounts of sensitive and confidential data could have been stolen.[83] A report a few months prior by Chinese antivirus company Qi-Anxin, which extensively analysed details on CIA software made public by Wikileaks, accused the agency of hacking Chinese firms with a particularly strong focus on the aviation sector.[84] Such activities were far from unprecedented and had been going on for decades.

US intelligence had also targeted China's political leadership at the highest levels, with a notable prior example being an operation to plant almost 30 surveillance bugs linked to American satellites on a US-made Boeing 767 aircraft. The airliner had just been delivered after a refitting to serve as Chinese President Jiang Zemin's official aircraft when the bugs were discovered. This left the aircraft, which had cost over $120 million, effectively unusable, although Beijing chose not to make a major issue of the incident amid broad efforts to improve relations at the time.[85]

American and Five Eyes espionage operations, and the cooperation they received from seemingly benign Western tech firms, notably far exceeded

anything alleged against China or Huawei. Silicon Valley tech firms in particular had developed very strong ties with American intelligence agencies, with *Reuters* citing former US officials and intelligence sources referring to "a long history of close cooperation between technology companies and the intelligence community." It highlighted:

> collaboration between the tech industry and spy agencies is both broader and deeper than most people realize, dating back to the formative years of Silicon Valley itself. As US intelligence agencies accelerate efforts to acquire new technology and fund research on cybersecurity, they have invested in startup companies, encouraged firms to put more military and intelligence veterans on company boards, and nurtured a broad network of personal relationships with top technology executives. And they are using those connections to carry out specific espionage missions, current and former officials say, even as they work with the tech industry to avoid overt cooperation that might raise the hackles of foreign customers.

This cooperation included working with American companies "to alter their hardware and software products to enable monitoring of foreign targets." An example of altering products to install backdoors was described as follows: "the government secretly created a computer reselling company to sell laptops to Asian governments. The reseller bought laptops from a company called Tadpole Computer, which made machines based on Sun Microsystems processors. The reseller added secret software that allowed intelligence analysts to access the machines remotely." When backdoors were not provided, defense contractors provided means "to break in to the products of virtually every major software vendor" and gain access more forcefully.[86]

Close cooperation between the Pentagon and intelligence services and major American tech firms went back to the Second World War era. A prominent Cold War era example was the funding by the US Defense Department's Defense Advanced Research Projects Agency (DARPA) of ARPANET in the 1960s, which later evolved into the Internet, to develop a communications network that could survive nuclear attacks. DARPA had long funded tech startups which could assist American security objectives, and in 2013 launched a fast-track program to provide such funding more widely. More recent examples of consumer technologies which had their origins in Pentagon funding through DARPA included Apple's Siri, GPS, iRobot and even self-driving cars among many others. While not every innovation that originated with DARPA funding ended up having applications that benefited American security interests, a great deal of them did.[87] The CIA too, beyond its aforementioned funding of potential competitors to Huawei, had for decades used its venture capital fund In-Q-Tel to finance tech startups that

could help further its objectives. Seemingly benign American tech firms thus often had behind them the interests of US foreign policy, which were often overtly hostile toward many of the countries and parties which were purchasing their services.[88]

Of the many and wide ranging of private sector startups supported and extensively shaped by the involvement of US intelligence services, perhaps the most notable example was Google which was seed-funded and strongly backed by the NSA and CIA. When Stanford University PhD students Sergey Brin and Larry Page developed the world's first automated web crawling and page ranking application, which later became Google's search engine, Brin reported regularly to representatives of a US intelligence community research program on information security and data mining. The students were among the many innovators in the field provided seed funding vital to their startup by the CIA and NSA, with their search engine seen as a valuable tool for managing large amounts of data and for surveillance and data mining. The involvement of intelligence agencies grew as what later became Google matured, with senior US intelligence representatives including a CIA official overseeing and contributing ideas to its pre-launch phase. Google subsequently received hundreds of thousands of dollars from investors connected with DARPA and the CIA's In-Q-Tel, and many of its most senior executives remained affiliated with the US military's private sector outfit the Pentagon Highlands Forum.[89]

Google and other tech giants which formed close ties to the intelligence agencies and military in their early days have continued to work closely with them to further American foreign policy goals. As former director of legislative and public affairs at the National Science Foundation, Jeff Nesbitt, observed in light of this long history of mutual support since Google's startup days:

> collaboration between the intelligence community and big, commercial science and tech companies has been wildly successful. When national security agencies need to identify and track people and groups, they know where to turn—and do so frequently. That was the goal in the beginning. It has succeeded perhaps more than anyone could have imagined at the time.[90]

Unlike Huawei which Western sources allege is tied to Chinese intelligence, but which has remained almost totally apolitical, American tech firms with thoroughly proven ties to the US military and its intelligence services have been strongly partisan in international issues in favor of both Western interests and Western ideology. A prominent example was the activities of senior fellow at the Council on Foreign Relations (CFR) think tank and a prominent State Department foreign policy advisor Jared Cohen in his capacity as the

director of Google Ideas. During Iranian anti-government protests and riots in 2009 Twitter notably delayed its scheduled maintenance to remain active for the specific purpose of helping to facilitate them based on Cohen's advice.[91] Cohen strongly advocated the use of emerging technologies and platforms such as social media to achieve Western foreign policy objectives and undermine Washington's adversaries, gaining him the name in some circles the "director of regime change."[92] He advocated use of information warfare to topple the governments the West labelled "undemocratic," expressing the belief in a global mandate for the Western world to intervene against, force change in, and remake countries in accordance with Western political values and ideology. He stated to this effect:

> Democratic states that have built coalitions of their militaries have the capacity to do the same with their connection technologies. . . . They offer a new way to exercise the duty to protect citizens around the world who are abused by their governments or barred from voicing their opinions. Faced with these opportunities, democratic governments have an obligation to join together . . . to bring about change. They must listen to those on the frontlines and recognize that their citizens' use of technology can be an effective vehicle to promote the values of freedom, equality, and human rights globally.[93]

One can only imagine the response by Western and allied media if a director at Huawei worked for China's foreign ministry, and if he expressed an almost missionary 'civilising mission' kind of ideological zeal in favor of spreading Chinese socialism as Cohen was expressing for the spread of Western liberal ideology.

Former State Department security official and American intelligence company Stratfor's Vice President for Intelligence, Fred Burton, noted regarding this public-private partnership to support US offensives: "Google is getting WH [White House] and State Dept. support and air cover. In reality they are doing things the CIA cannot do."[94] Jared Cohen formerly worked as an advisor to Secretary of State Hillary Clinton, and in 2011 sought to encourage members of the Syrian military, who were then engaged in battles with US-backed insurgents, to defect. Cohen consulted with the State Department before Google launched a 'defection tracker,'[95] which according to leaked emails from Secretary Clinton was "designed to encourage more people to defect and give confidence to the rebel opposition."[96] Cohen had worked across the world with groups ranging from Afghan companies, Islamic religious authorities and Indian film industries, among many others, to further US foreign policy agendas. His activities and statements were a strong indicator of the extent of the partnership between the State Department, intelligence agencies and tech giants to undermine Washington's targets.[97]

Google actively worked to closely support Western-backed anti-government militias in wars in Syria and Libya in 2011. Google Maps, for example, renamed various streets in government-controlled Damascus after Islamist insurgent leaders, effectively wiping the internationally and UN recognized Syrian government off the map. Key sites in the Libyan capital were similarly renamed by Google in accordance with the names given by Western-backed insurgent leaders. These actions reflected the tech giant's strong political stances against the two Arab governments which had long opposed Western interests in their regions, and was one of the more basic ways Google could support Washington's war efforts against its targets.[98] The *New York Times* later reported that Google had sponsored training, meetings and preparations for groups and individuals directly involved in revolts and unrest in the Arab world alongside the State Department, Facebook, Google, MTV and Columbia Law School. Skills provided included using social networking and mobile technologies to promote calls for political change along Western lines.[99] One of the conferences was attended by State Secretary Hillary Clinton and representatives from the State Department, Google and Facebook, with the tech giants playing important role in hosting the events.[100] The nature of ties between US tech giants and its government and intelligence services, and the highly politicized nature of the activities of firms such as Google, discredited the notion that unevidenced allegations of much more limited cooperation between Huawei and China's security services could pose any kind of unique threat to the world even if true.

In 2013 details emerged that thousands of technology, finance, manufacturing and other companies were working closely with US intelligence agencies and providing sensitive information particularly on their overseas clients. In return they often received classified intelligence from government agencies which was beneficial to their work and could provide advantages over foreign competition. Western firms ranging from hardware and software producers, banks, Internet security providers and satellite telecommunications companies among many others voluntarily provided data for use by US intelligence or cyber warfare units. An example was the provision by Microsoft and other software companies of information on software sold to foreign governments, which assisted American intelligence agencies in exploiting vulnerabilities. Firms such as Google also played a key role in the NSA's Prism program which gathered e-mails, videos, and other private data of foreign surveillance targets through arrangements with the tech companies. Much of the kind of information provided by firms to intelligence agencies was termed by Western experts to be "highly offensive information," as opposed to "defensive information" which was used to protect one's own systems rather than attack others.[101]

As the campaign against Huawei premised on its alleged threat to security escalated in the final months of the Donald Trump administration, several key indicators emerged regarding the nature of the security threat which the US and its intelligence partners were posing on a global scale. In a published statement in October 2020, following on from very similar statements the two previous years, representatives of the United States, Britain, Australia, Canada and New Zealand in their capacities as members of Five Eyes called for tech companies to build more encryption backdoors into their systems. Western intelligence agencies sought to have tech firms provide access which was substantive and genuinely influenced design decisions in order to allow these agencies to penetrate communications globally.[102] Five Eyes was openly asking Western tech firms to do exactly what US officials had repeatedly alleged without evidence that Huawei had done for the Chinese government. NSA penetration of Huawei had proven that the firm did not engage in such practices, and it was US and not Chinese intelligence which had stealthily introduced surveillance backdoors into Huawei's equipment.[103]

A report three months prior in August 2020 from the *Wall Street Journal* showed that a federal contractor with ties to the US defense and intelligence communities, Anomaly Six LLC, paid mobile developers to embed government tracking software within their applications. This allowed it to secretly track the movements of hundreds of millions of mobile phones worldwide. Anomaly Six had been founded by two US military veterans with intelligence backgrounds, and its software had affected more than 500 mobile applications. The data acquired was then sold back to US government agencies.[104]

In November it emerged that the US military was purchasing granular movement data of internet users across the world through applications. These ranged from Muslim prayer and Quran apps, which had over 98 million downloads worldwide, to apps for following storms, for DIY home appliances and for dating.[105] This was hardly unprecedented, with a notable precedent being the US military's use of similar kinds of signals intelligence to organize drone assassinations overseas.[106] In January 2021, an unclassified memo obtained by the *New York Times* showed that analysts at the Defense Intelligence Agency bought databases of US smartphone location data in recent years without court warrants to keep track of the movements of Americans.[107] Less than a month later, it emerged in early February 2021 that the Department of Homeland Security had similarly used data from phone applications to maintain border security—hardly a malign purpose in this case but still demonstrative of the extent to which the US government used seemingly benign commercial products and services for intelligence gathering purposes.[108]

WHAT IF HUAWEI WAS SPYING?

Although Western allegations against Huawei have been unevidenced it is worth exploring the possibility that they are indeed correct, and that for whatever reason those seeking to turn world opinion against the Chinese firm had some concrete evidence against it but chose not to share it.[109] FBI Director Christopher Wray accused Huawei of "pervasive criminal behavior" designed to "undermine our country's place in the world," while *Time* highlighted in 2019 that the firm *"*may be the most controversial company in the world" on the basis of its alleged role as a tool for intelligence gathering. Such claims were repeated across Western media.[110]

The primary allegation against Huawei was that it was being used as a tool for Chinese intelligence to survey the world. This was hardly more dangerous that what American intelligence had been doing for decades through its own tech firms, and on a far greater scale than was even being alleged of Huawei. Huawei as a supposed tool for Chinese surveillance was not about to drastically reduce the privacy of people or governments across the world, with US and Five Eyes surveillance having already established this as a norm of the twenty-first century.

If it were indeed a tool for spying, proliferation of Huawei technologies could be seen as a means to partially even the odds in a world where almost every person in every country could be targeted and was having data collected on them by a massive US-led Western surveillance apparatus. Even if the most extreme Western allegations were true, Huawei would never be able to provide Chinese intelligence with even a fraction of the data which the vast Western spying apparatus was. If Huawei was indeed hypothetically a tool for spying, then Chinese intelligence would only be doing what US and Western intelligence had been doing for decades—using indigenous tech giants to increase their surveillance capacity and further foreign policy objectives. As Australian columnist Peter Kammerer observed:

> Apple and Samsung smartphones, voice assistants like Siri and Alexa, Facebook and Google, among so many others, collect and store and even share endless amounts of data about us whenever we activate them. Those big tech companies often also work with governments and militaries and it's anyone's guess what gets passed on, as whistleblower Edward Snowden so helpfully revealed in his leak of United States spy agency documents. To trust one and not the other, simply because one is Western and the other Chinese, is nothing but xenophobia.[111]

If governments were indeed persuaded that Huawei could be used as a tool for espionage, their decision on whether to use it would likely be determined by whether they perceived Chinese or Western espionage to be the greatest

threat. As it was, however, the NSA's deep penetration of Huawei and Edward Snowden's subsequent leaks from the agency very strongly indicated that Huawei, unlike so many of its Western counterparts, was clean, apolitical and had no ties to China's security apparatus.

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109. Despite allegations against Huawei lacking evidence, many analysts considered negative coverage of and resulting growing public sentiment against Huawei in the West to be the result of its Chinese origin. Some compared coverage of suspected but unproven Huawei espionage to the much more mild coverage of the Israeli software firm NSO Group which was found to have been used by governments to wiretap journalists and public figures targeting 50,000 phones. NSO Group, unlike Huawei, did not undermine Western geopolitical interests and was based in a state which generally upheld and supported Western-led order. As a result the discrepancy in how the scandal surrounding it was covered, and how a similar scandal surrounding Huawei would inevitably have been covered if it ever occurred, was very considerable. ('Where's the Rage for Israel and NSO's Pegasus the West Had for China's Huawei?,' *Sputnik,* July 21, 2021.)

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PART III

How Global Markets Chose China

Chapter 8

American Industrial Decline from Apple to Lockheed Martin

A STRONG COMPETITIVE EDGE: WHY INDUSTRY WON'T MOVE BACK TO THE WEST

China's rise has been fueled primarily by its cultivation of economic conditions which market forces in an increasingly globalized world deemed in many respects the most efficient, which consequentially propelled the country toward growth. Development of such conditions can be traced back to the founding of the People's Republic in 1949, long before China's adoption of a market economy, when tremendous progress was made in developing a basic industrial base and in fostering and drastically raising the value of human capital. Between 1949 and the beginning of market reforms in the 1970s rapid improvements in literacy rates and general education, life expectancy, disease eradication and the general public health and the ending of a century of widespread opium addiction, were phenomenal feats with few parallels in world history.[1] The state of all of these development indicators before 1949 had been among the very worst in the world. Although China was still far from affluent when market reforms began, it was certainly much wealthier than it had been when the People's Republic was founded and had made the investments in human capital needed to compete effectively when integrated into global markets.[2] It was only with a healthy, literate and technically competent workforce that China could begin to attract capital investment from across the world and over the next forty years transform itself into by far the world's foremost industrial power.

Four decades after China had adopted a market system and reoriented its economy to focus heavily on international trade, the United States faced increasingly unfavorable economic and technological power trajectories. In

a globalized world America's less efficient economy portended a continued erosion of its less competitive industrial base and a rise in Chinese power. This fueled calls in Washington's for a turn away from globalization and international economic integration and toward decoupling, government intervention, and protectionism. The US had adopted a neoliberal economic system in the 1980s under which government had a minimal role and the free market was largely given free reign—a laissez faire approach that had very significant economic and geopolitical consequences.[3] To a limited extent following the 2008 crisis,[4] but much more so from the late 2010s in the face of Chinese competition, this system increasingly came to be seen as having eroded American power and to be unsustainable.[5]

A growing drive in the US toward decoupling the economies of America and the West from much of the wider world, and from China in particular, was fueled by hopes that this could preserve American and Western power in the face of China's more competitive economy. President Donald Trump frequently gave voice to this popular sentiment, tweeting on August 23, 2019, regarding his unwillingness to enter trade talks that "we don't need China and, frankly, would be far better off without them."[6] As calls for decoupling gained momentum, proponents of this policy position increasingly sought to portray economic integration with China as having been mistaken from the outset. The US trade representative under the Trump administration Robert Lighthizer, for one, argued in May 2020 that allowing the private sector to freely offshore American manufacturing was a "misguided experiment" from the outset.[7] Permitting China to join the World Trade Organization in 2001, which allowed it to compete on a more level playing field with Western economies and fueled years of very rapid Chinese economic growth, was also portrayed as a regrettable policy error. As an article in the *Wall Street Journal* observed in July 2018: "In the administration's view, allowing China to enter the WTO in 2001 was a historic mistake that cost the US millions of jobs and trillions of dollars in accumulated trade deficits. The US is now bypassing WTO rules and threatening Beijing with tariffs on up to $500 billion of imported goods."[8]

From the president of the Information and Technology Innovation Foundation Robert Atkinson, to former Clinton security advisor Kurt M. Campbell, to analysts at *The Atlantic* and *The American Economic Review*, retrospective criticisms of China's WTO accession became increasingly widespread.[9] As *Foreign Policy* observed, even outside Trump's administration "many point to China's accession to the WTO as the original sin."[10] This narrative often stressed that the greater Sino–US economic integration that followed disproportionately benefited American political elites and corporations at the expense of the country's population and long term national interests, and allowed China to emerge as a leading economic competitor

at America's expense. An annual report to Congress in 2018 from the US Trade Representative's office stated to this effect: "It seems clear that the United States erred in supporting China's entry into the WTO." The report attempted to explain the fact that Beijing was not in violation of the organization's terms, and that there were no signs that it was not 'playing by the rules' in international trade, by claiming that the terms themselves were "not sufficient."[11] Ironically, while the WTO did not find fault with China's trade policies, it ruled American protectionist trade policies toward China to be in violation of the organization's trade rules.[12]

The US rationale for allowing China's accession to the WTO, a decision which would be nearly impossible to reverse,[13] had been argued for on both economic and ideological grounds. Allowing it to enter was seen as a way to westernize China's economic and system, its society and eventually its politics, which were key Western objectives in the post-Cold War years. Such a process was seen as inevitable as part of the US and European view of the 'end of history,' which equated to global westernization in the wake of the Soviet collapse. As President Bill Clinton stated to this effect in March 2000, when arguing for Chinese accession as a congressional vote on the matter was looming: "By joining the WTO, China is not simply agreeing to import more of our products, it is agreeing to import one of democracy's most cherished values, economic freedom. When individuals have the power not just to dream, but to realize their dreams, they will demand a greater say."[14] The assumption that economic liberalization would accelerate a move toward political westernization in China was widely made in the West, and persisted long past the Clinton administration.[15]

Beyond designs to remake China in the West's image, which was a geopolitical and ideological goal that was key to gaining widespread support for China's accession, US firms also sought to benefit considerably from Beijing joining the WTO. As the George W. Bush administration's trade representative at the time China joined the WTO, Robert Zoellick, stated: "What many critics overlook is that China already had access to US markets. The United States didn't give up anything—China made concessions to join." Such concessions included further opening its markets and providing a much more favorable terms for Western firms both to export their goods and to invest. As a member, China in turn gained greater access to the markets of all WTO members, the prohibition of protectionist treatment by other members to advantage their own firms over Chinese ones, and a ban on increased tariffs on Chinese goods by other members.

Regarding retrospective claims that China's accession to the WTO was a negative development, Zoellick stated: "This is a theme, a new piece of the conventional wisdom, that cooperation has failed—and that assumption is flat wrong. On proliferation, the global financial crisis, the environment,

security—there are a lot of areas where cooperation has served US interests."[16] A stronger Chinese economy was also in a much better position to service American debt and assist the US in recovering from the 2008 financial crisis, which it would not have been able or as willing to do if there had not been a robust trading relationship largely facilitated by both countries' WTO membership.[17] For its important role in supporting the US economy in the aftermath of the crisis, China had been referred in the West as "the world's shock absorber"[18] and as having "saved the world."[19] After 2008 the US was widely seen to rely much more on China than vice versa for its economic well-being, with China's massive stimulus packages that had ripple effects for Western economies having played a pivotal role in preventing a far more serious economic decline.[20]

Although China's economic ascent was made easier by WTO accession, US economic interests on both the corporate and consumer levels were also prime beneficiaries.[21] A 2018 working paper for the Bureau of Labor Statistics by economists Xavier Jaravel and Erick Sager found that Chinese import competition between 2000 and 2007, at the height of the so-called 'China shock' period, had significant "pro-competitive effects" on American firms and generated over $202 billion in consumer benefits via lower prices. That equalled $101,250 in benefits to US consumers for each manufacturing job lost.[22] A study the following year published in the *American Economic Review* found that imports from China "significantly reduced inflation," cutting the price index for consumer goods by 0.19 percentage points per year between 2004 and 2015. This was a result of both changes in the prices of existing goods and the entry of new goods, and signalled both strong pro-competitive effects and improved variety.[23] A 2017 study by the Vice President of the Microeconomic Studies Function at the Federal Reserve Bank of New York, Mary Amiti, reached many of the same conclusions.[24] Further studies from the National Bureau of Economic Research, the University of Chicago and others found that while America's poor and middle class were the primary beneficiaries of international trade, this was even more pronounced in the case of trade with and particularly imports from China. American manufacturing was also widely found to have benefited.[25]

According to research carried out at the Federal Reserve Bank of San Francisco, approximately fifty-six cents of every dollar Americans spent on 'Made in China' imports in 2018 actually went to American firms and workers—the highest share of any country exporting to the US. Chinese imports had a net benefit for American jobs in transportation, logistics, construction, maintenance and repair among others.[26] As noted in a detailed 2020 study by the CATO Institute, written by Senior Fellow Scott Lincicome, the US had benefited immensely from China's accession to the WTO and from economic

integration, with American firms and the working and middle classes being the primary beneficiaries. The study concluded that accession and integration:

> produced real economic benefits for most Americans while bolstering the multilateral trading system and removing historical inequities under the previous, more protectionist US trade policy regime . . . the facts simply do not support popular assertions from American politicians and pundits that engagement with China in the 1990s and 2000s was an obvious mistake and that denying China admission to the WTO was realistic a policy choice that would have improved US economic and geopolitical standing today or that the real labor and cultural issues in America today are the fault of 'Washington elites' who blithely pursued normalized trade with China to benefit corporate donors and democratize communist China while dogmatically refusing to support—through trade, labor, or any other policies—the working class. Such narratives are unsupportable.[27]

While China's WTO accession may have strengthened the country relative to the United States by narrowing the economic disparity between them, its net effect was to significantly strengthen both economies.

Only by understanding the importance of the trading relationship with China, and America's inability for a wide range of economic reasons to revert to a protectionist stance and reliance on domestic industries, can the immense difficulties if not impossibility of a radical decoupling be properly comprehended. The American industrial base notably remained in a very poor position to take over manufacturing from China, no matter how great the tax incentives were and how heavily the government intervened. Despite admonishments from President Trump among others in the US leadership "to start building their damn computers and things in this country,"[28] major technology manufacturers would find it almost impossible to relocate their production lines to the Western world ever again. A notable example of why this was the case came in the mid-2010s and involved Apple's efforts to relocate some manufacturing to the US.

In 2012 Apple's chief executive Timothy D. Cook announced on television that Apple would begin manufacturing its top-of-the-line Mac Pro desktop computers in the United States—the first Apple product in years to be built by American workers—and that they would bear the inscription 'Assembled in USA.' The Mac Pro was Apple's least widely sold computer internationally by a considerable margin, and was designed largely for specialist use with a price as of 2021 ranging from $6000 to over $60,000. It was produced on a very small fraction of the scale of more popular designs such as the MacBook or iMac, let alone the iPhone series from which Apple earned the bulk of its revenues. The transfer was nevertheless widely hailed by many American media outlets and political commentators as a step in the right direction—away from China and back to supporting American workers. The specialist

nature of the Mac Pro and its resulting small scale of production were very seldom raised.

Apple notably encountered significant difficulties when seeking to assemble the Mac Pro in the US, with the *New York Times* highlighting as an example a seemingly mundane issue which turned out to be critical—the lack of suitable screws in America. In China Apple had access to multiple factories which could produce large quantities of customized screws on short notice, but this was far from the case in the United States. As the *Times* noted:

> In Texas, where they say everything is bigger, it turned out the screw suppliers were not. Tests of new versions of the computer were hamstrung because a 20-employee machine shop that Apple's manufacturing contractor was relying on could produce at most 1,000 screws a day. The screw shortage was one of several problems that postponed sales of the computer for months, the people who worked on the project said. By the time the computer was ready for mass production, Apple had ordered screws from China. The challenges in Texas illustrate problems that Apple would face if it tried to move a significant amount of manufacturing out of China. Apple has found that no country—and certainly not the United States—can match China's combination of scale, skills, infrastructure and cost.[29]

Being so far from industry supply chains, which were overwhelmingly centered in Northeast Asia and in China in particular, significantly complicated operations, raised logistical costs and undermined the flexibility needed to tweak and adapt manufacturing processes. The *Times* noted a wide range of issues which caused materials to be regularly out of place and led to considerable delays when attempting to manufacture products in the US due to the far smaller industrial base there. It found that Apple continued to produce a small number of Mac Pros in America because it had already sunk investment into complex machinery there—not because this turned out to be particularly efficient once production had begun.[30] *Business Insider* similarly concluded that the investment in 2017 was a "small political gesture . . . which is already a financial and operational headache for the company"—one which Apple would otherwise rather end.[31]

Not only are China's economy and labor force particularly well suited to manufacturing complex high-end industrial goods, both for foreign companies and increasingly for its own emerging tech giants, but the US and the vast majority of the Western world are particularly poor in this area. As Tim Cook observed regarding China at a conference in December 2017 and the level of knowhow needed to manufacture and operate state-of-the art machinery which made Apple products: "The skill here is just incredible . . . In the US, you could have a meeting of tooling engineers and I'm not sure we could fill the room. In China, you could fill multiple football fields."[32]

Cook's predecessor Steve Jobs had made statements to much the same effect, famously concluding when asked by President Obama about the possibility for repatriation of jobs: "those jobs aren't coming back."[33]

An article from *Forbes* in early 2018 noted regarding the difficulty Apple would face if manufacturing one of its non-specialist products, the iPhone, in the US:

> If Apple were forced to solely manufacture the iPhone in America, there is a good argument that it would not be able to manufacture any at all. And if they could somehow successfully make the manufacturing transition, capacity would likely be constrained to a just a few million units a year. The issue here is not really about differences in the cost of labor. It is more about the supply chain and it is mostly about differences in the necessary skills required to manufacture hundreds of millions of iPhones at high-quality to satisfy current market demand.[34]

The unique nature of China's advantages meant that, while the possibility of tech giants reshoring manufacturing to Western countries remained negligible, even prospects for moving industry from China to other Asian countries remained slim. These advantages went far beyond labor costs, as Tim Cook noted:

> There's a confusion about China . . . the popular conception is that companies come to China because of low labor cost. I'm not sure what part of China they go to but the truth is, China stopped being the low labor cost country many years ago and that is not the reason to come to China from a supply point of view . . . the reason is because of the skill . . . and the quantity of skill in one location . . . and the type of skill it is. The products we do require really advanced tooling. And the precision that you have to have in tooling and working with the materials that we do are state-of-the-art. And the tooling skill is very deep here.[35]

Cook noted that China benefited from "very deep" vocational expertise, for which he credited the country's education system, noting that it was ahead of the curve in emphasizing vocational aspects of education which had given industry a significant edge.[36] He stated on a separate occasion that "there has to be a fundamental change in the education system" in the US for Apple to be able to consider moving production to America, which was something his predecessor had also alluded to.[37]

Even half a decade before Cook's statement, the *New York Times* had observed to much the same effect: "It isn't just that workers are cheaper abroad. Rather, Apple's executives believe the vast scale of overseas factories as well as the flexibility, diligence and industrial skills of foreign workers have so outpaced their American counterparts that 'Made in the USA.'

is no longer a viable option for most Apple products." The fact that China "provided engineers at a scale the United States could not match," and could assemble the numbers required in fifteen days where the US would take nine months, was another major factor. It highlighted that this was a trend which forced companies to offshore to remain competitive in fields as wide ranging as banking, pharmaceuticals, and auto manufacturing. As an Apple executive cited by the *Times* noted: "We shouldn't be criticized for using Chinese workers. The US has stopped producing people with the skills we need."[38] This was an assessment he was far from alone in making particularly in regard to engineers.[39]

A former high-ranking Apple executive cited by the *Times* was one of many sources to stress the importance of the concentration of global supply chains in China, stating: "The entire supply chain is in China now. You need a thousand rubber gaskets? That's the factory next door. You need a million screws? That factory is a block away. You need that screw made a little bit different? It will take three hours."[40] The concentration of supply chains was an aspect Tim Cook also strongly emphasized as a primary factor which influenced where manufacturing took place.[41] As a result of the unique advantages China offered, should tech giants such as Apple seek to diversify their production as Sino–US relations deteriorated there would be no alternatives with any remotely comparable capabilities whether in terms of their industrial base and concentration of supply chains or the combination of size, competence and cost effectiveness of their skilled labor force.[42]

The result of Apple's brief experiment with manufacturing in the United States was indicative of a major phenomenon which underlay a key trend in the global economy. It signified how shifting even a very small production line required much more than one or two new lines being built—it required the movement of an entire production ecosystem which was unlikely to ever return to the Western world. Facing political pressure, Apple was willing to experiment with accepting the higher costs of producing a single specialist computer in America—albeit largely relying on components made abroad—with underwhelming results. With inefficiencies leading to higher costs across the production lines, often several times as high, the movement of an entire production ecosystem back to the West would be very far from profitable and would incur additional costs at all stages of production, from manufacturing the screws in America to finally assembling the computers themselves. The result, if Apple were to theoretically relocate its much larger production lines to the US, would be a price increase of several hundred percent, according to some estimates over 1000 percent, for its major products due to the very significant decrease in efficiency.[43] This would not only end a firm's ability to compete internationally, and thus strip its vital economies of scale, but no realistic amount of tariffs on imports could make it viable even in the US

market. Even with a 200 percent tariff, foreign smartphones and computers would still be cheaper.

AMERICA'S DEFENSE INDUSTRY DECLINE

The trend toward Western products being unable to rely on domestic manufacturing as a result of the economic shift to East Asia, and to China in particular, notably also had strong implications for the US and European defense sectors. Although this was one of very few areas where the United States committed itself to remaining a leader in manufacturing, even a world leading military industry could not remain completely self-reliant in the long term in a largely deindustrialized country as an island of its own. This was true no matter how many hundreds of billions of government funds were invested in it annually.

Great power status over centuries has long been seen almost unanimously by experts to depend on a state's economic base and manufacturing sector, which had to at least be sufficient to furnish its armed forces without depending too heavily on external support.[44] The US not only lagged far behind China in this regard, but by the 2020s had fallen to a level of self-sufficiency more comparable with the military industrial bases of Russia or North Korea which, while the US was declining, had in the 2010s partially recovered from their own post-Cold War declines.

A review ordered by President Donald Trump and led by the Pentagon found in 2018 that the US military had come to rely heavily on foreign products, and especially those from China, for its operations. Notable among these were micro-electronics, integrated circuits and transistors, which were all very widely used in military hardware ranging from satellites and guided missiles to combat aircraft and communications systems. Beyond electronics, reliance on Chinese manufacturing also included products such as the chemical Butanetriol used to produce Hellfire missiles. *Reuters* noted regarding this development: "The Pentagon has long fretted that 'kill switches' could be embedded in transistors that could turn off sensitive US systems in a conflict." An anonymous US official told *Reuters* regarding the findings of the investigation: "People used to think you could outsource the manufacturing base without any repercussions (on national security). But now we know that's not the case."[45]

The investigation ordered by President Trump highlighted the need to support niche manufacturers in the United States producing hardware which was key to its weapons systems. Government intervention to keep noncompetitive niche producers operating could slow the worsening of the issue, but ultimately would not solve it.[46] Even if issues of reliance on East

Asian-manufactured hardware were remedied, broader trends in the economy guarantee that doing so would incur significant costs for the US military which by 2021 was already outspent by China's armed forces on acquisitions.[47] Using government subsidies to prop up domestic producers was a temporary solution, and far from an efficient one.

As the *National Interest* highlighted in the title of a prominent article in 2018: "The US military's Greatest Weakness? China 'Builds' a Huge Chunk of It." It stated regarding the challenge this potentially posed to American security: "when it comes to America's weapons, Made in China is a label you don't want to see . . . America's war machine runs on advanced electronics, most of which are made abroad. Ninety percent of the world's printed circuit boards are manufactured in Asia, and more than half in China." The publication emphasized, however, the underlying reality that signs of moves by the US to eliminate China from its military's supply chains "may be more smoke than fire" due to the likely unfeasible cost of moving manufacturing back to America, stating:

> Short of nationalizing American defense contractors, the US will depend on private industry to satisfy its military production needs. And private industry—or their Wall Street shareholders—will insist on minimizing costs and maximizing profits. That's the essence of globalization, and the impetus for the relentless outsourcing of American manufacturing. That why Chinese goods have so captured so much of the US market . . . Made in America makes great sense in terms of national security, but American taxpayers will have to be willing to pay extra for Made in Seattle instead of Made in Shanghai.

As a consequence of the tectonic shift in the global economy toward East Asia, the *National Interest* further questioned "whether it is even possible anymore to make purely American weapons." It made grim predictions for the possibility that reliance on Chinese industry by the US military would decline, and stated regarding the financial difficulty of any drastic moves away from this that: "the Pentagon tries to save money by buying commercial-off-the-shelf technology instead of custom-made gear, but the commercial sector relies on Chinese-made components, especially electronics . . . transforming into Made in America will not be cheap or easy."[48] As US defense journalist Brett Tingley was one of many to underline: "currently, the US is almost entirely reliant on foreign-made electronics to power most of its technologies, both in the defense and consumer sectors." He stressed that this had very significant implications not only for civilian high tech's ability to compete, but also for the defense sector.[49]

The pervasive nature of the US military's reliance on China-sourced hardware was such that in several cases the Chinese origin of various items was

unknown to the Pentagon. New York tech company Adventura Technologies notably sold Chinese-made equipment to the Pentagon for years by claiming it was built in America, reaping considerable profits in the process. This primarily included surveillance equipment. Hardware was notably repackaged in boxes with 'Made in the USA.' labels and stars-and-stripes logos. While this could potentially be written off as an individual case of fraud, it served as an indicator of a much more serious underlying issue. So long as the gap in competitiveness and efficiency between the manufacturing sectors of the two countries was so great, there would always be a strong incentive not to use American-sourced products and to attempt to substitute them at any point in vast value chains that supplied the military. This provided the underlying incentive for Adventura Technologies' actions. The gap in profitability was so great that it was seen to be worth taking a tremendous legal risk, which in this case happened to be found out but, in many others, may not be.[50]

Alongside reliance on Chinese manufacturing, the issue also emerged that Western firms supplying to the US military could be under Chinese ownership amid growing acquisitions by Chinese firms. A notable example was the F-35 fighter program, which for many years was the only fighter the US Air Force had on order with over 1,700 planned,[51] and which aside from its heavy reliance on Chinese exports of rare earth materials[52] was found in 2019 to be using components from a Chinese-owned firm based in Britain. This was initially denied by the F-35's main contractor, Lockheed Martin, but was later confirmed.[53] Industry trends dictate that this is likely to continue to occur widely, although many cases may not become known to the public.

The trend toward reliance on foreign suppliers for defense and the hollowing out of the American military industrial base emerged soon after the end of the Cold War. Although very high defense spending in the Reagan and H. W. Bush years had left the defense sector relatively isolated from the early stages of the country's industrial decline, defense expenditures fell sharply after the Warsaw Pact disintegrated and the USSR collapsed which led to a sharp deterioration in the defense sector from the 1990s.[54] Erosion of parts of the US industrial base needed for military procurement became increasingly evident around the turn of the century, with steep declines in domestic sourcing for production of critical systems such as aircraft parts and engines as a percentage of overall sourcing. Deterioration had been particularly rapid in the 1992–1996 period but continued long afterwards, with pressure on manufacturers to increase efficiency amid declining budgets cited as a major cause which very often resulted in outsourcing overseas. This came as part of a broader trend that was seen to an even greater extent in the civilian sector. For example, the decline in the percentage of American inputs in building military aircraft and ships came amid faster outsourcing in the civilian aviation and shipbuilding industries. While policy recommendations were made

repeatedly from the early 2000s, Washington and the Pentagon ultimately proved unable to turn back the tide toward outsourcing of vital sectors of production overseas with much of it going to China.[55] Market forces dictated that, even in the defense sector where government intervention was most pronounced, the trend toward moving manufacturing overseas, and to China in particular, was strong.

A notable indicator of the extent of the US military's post-Cold War reliance on foreign suppliers came in 2003 when a bill introduced by Representative Duncan Hunter would have required that US content in defense products rise from 50 percent to 60 percent, and that four years after enactment all machine tools in US defense programs be 100 percent domestic. The White House argued that this had "the potential to degrade US military capabilities" and more specifically would "unnecessarily restrict the Department of Defense's ability to access non-US state-of-the-art technologies and industrial capabilities." Even raising the US content minimum to 60 percent was seen to be too difficult, and while it would have been a more than reasonable goal before the 1980s the deterioration of domestic industry and globalization of supply chains meant that this was no longer realistic.[56] Similarly, the Aerospace Industries Association in 2003 opposed calls for greater reliance on US-made equipment on the basis that restricting foreign imports would not only significantly raise the costs of defense products, but it would also prevent access to many of the most advanced electronics and information technologies. It highlighted flat panel displays, which were no longer made in the United States, as an example.[57]

Principal and Founder of the High Road Strategies economic policy research consultancy, Dr. Yudken Joel, noted in a prominent paper in 2010 that the argument over whether to produce defense equipment domestically or outsource it abroad served to "highlight the fundamental challenge the nation confronts in maintaining a strong defense industrial base—the continuing decline in US manufacturing." The paper was titled: 'Manufacturing Insecurity: America's Manufacturing Crisis and the Erosion of the US Defense Industrial Base,' and stated:

> The Pentagon embraced policies to globalize the American defense industrial base. Rather than relying on its traditional US suppliers, the Pentagon increased both its openness to shopping overseas for weapons systems, and its tolerance for foreign purchases of US defense businesses. Pentagon officials argued that the foreign sourcing of products, components, and materials would actually be a good thing for all but the most defense-critical technologies, even claiming that this would lead to faster innovation while cutting costs . . . industry and labor leaders, as well as Congress members, have warned that the Pentagon's policy of increasing this [foreign] dependency will contribute to the erosion of

> the nation's defense industrial capacity, and consequently, undermine national security.[58]

The Pentagon's 'Industrial Capabilities' annual reports on the defense industrial sector showed that while the industry continued to make significant profits, a concerning number of key components could not be supplied domestically. The closure of niche manufacturers and the lack of technical skills were key causes and represented part of a broader trend toward industrial decline. Taking 2018 as an example, cases ranged from a key producer of missile components having closed for two years before the Pentagon found out, to key suppliers of aircraft parts that faced "perpetual financial risk and experience bankruptcy threats." The 2018 Industrial Capabilities report also pointed to "a generation of engineers and scientists that lack experience in conceiving, designing, and constructing new, technologically advanced combat vehicles."[59]

Reports also highlighted a diminishing share in many key export markets, with a market share in global naval weapons exports falling sharply from 63 percent in 2007 to just 17 percent in 2017. This reflected a broader trend toward decline in American shipbuilding. A decline in the military shipbuilding industry had seriously restricted the diversity of suppliers, which inevitably led to higher costs, lower efficiency and lower redundancy, with the report highlighting significant risks from "dependence on single and sole source suppliers, capacity shortfalls, a lack of competition, a lack of workforce skills, and unstable demand."[60] The 2018 report also cited statistics from the Department of Labor predicting a decrease of up to 17 percent in US jobs in occupations critical to Navy shipbuilding projects, "such as metal layout, welding, and casting" between 2018 and 2026. If not addressed, a lack of skilled workers "will significantly impact the shipbuilding industry's ability to meet the Navy's long-term demand," it noted. Further serious issues were found in the munitions sector, and reports in subsequent years indicated no significant improvements and in many fields only more serious decline.[61]

Taking the decline of military surface shipbuilding as an example of broader decline in the military industrial base, the costs and performances of America's post-Cold War surface warship designs served as indicators of this problem. The Zumwalt Class destroyer, for example, suffered serious cost overruns and performance issues leading to over 90 percent of planned ships being cancelled. The three that were completed had seriously watered-down capabilities, questionable reliability and practical use, and cost over $7 billion each—while suffering from a wide range of significant other issues.[62] The *National Interest* referred to the destroyers in 2020 as "overbudget ships that don't even work" and "floating boondoggle," which reflected a broad consensus among analysts with multiple similar assessments made.[63] An example

of one issue was that producing munitions for the ship's gun proved impossible at under $800,000 per round, and with each ship designed to carry two guns with 920 round magazines firing ten rounds per minute the extreme cost forced the Navy to remove the Zumwalt's primary weapons entirely.[64] The Zumwalt was notably America's only post-Cold War program for a destroyer or cruiser sized warship. Other programs such as the Littoral Combat Ship and Gerald Ford Class aircraft carrier,[65] which like the Zumwalt were the only post-Cold War ships classes of their kind, were by some accounts even more problematic. The former began to be retired decades ahead of schedule due to serious performance issues after suffering from tremendous cost overruns and performance inefficiencies,[66] and itself was hardly the only new warship forced into a very early retirement.[67] These supposedly cheap and small ships with a negligible armament ended up costing more to operate than a heavy destroyer and three times as much to produce as late Cold War era destroyers.[68]

The Gerald Ford Class supercarrier, meanwhile, continued to suffer very serious performance issues affecting areas from its lifts and catapult systems to its sensors and sewage pipes. Taking sewage as an example, pipes were reportedly far too thin to accommodate quantities of sewage from the carrier's crew and required a regular flushing of the entire system with acidic substances costing $400,000 dollars per flush. The pipes suffered major clogging issues, and unless replaced these costs would be incurred by the navy on a regular basis.[69] Approaching five years after the first Gerald Ford Class carrier was commissioned, it was still very far from ready for even medium intensity combat.[70] Furthermore at over $13 billion, even when adjusting for inflation, the ship still cost over twice as much as its immediate predecessor the Nimitz Class which was the same size and had many significant similarities but which had been designed during 1970s when the American defense sector was much more robust.[71] The state of the US Navy's fast declining shipyards and maintenance capabilities was similarly if not much more serious.[72]

Reports from the National Defense Industrial Association (NDIA) on the defense industrial base pointed to many of the same trends as those from the Pentagon. The association's report from 2020, titled 'Vital Signs 2020: The Health and Readiness of the Defense Industrial Base,' indicated strong negative trends with firms struggling with deteriorating conditions for industrial security and the availability and cost of both materials and skilled labor. Grading various aspects of the industrial base it showed that the security of supply chains was by far the biggest problem followed by political and regulatory issues. Defense industry production inputs needed to manufacture or develop end-products for the Pentagon were highlighted as problematic and rated poorly, with the production inputs considered including skilled labor,

intermediate goods and services and raw materials. A report the following year painted much the same picture.[73]

A White House report on the Manufacturing and Defense Industrial Base and Supply Chain, which had been specially requested by President Trump and was published in September 2018, strongly concurred with those from the Pentagon and the NDIA in pointing to a defense industrial base severely eroded to levels that left national security seriously at risk. "All facets of the manufacturing and defense industrial base are currently under threat," it found, and there were entire "industries near domestic extinction" which forced the Pentagon to increasingly look overseas for supplies. As the *Washington Post* noted regarding the report's findings, "the vast supply chain serving the US military has become dependent on low-cost foreign components . . . Things such as machine tools, infrared detectors and night-vision systems are largely provided by foreign suppliers, officials say, raising questions about whether the US military would have access to them in a protracted war." This was in part a result of a "broken procurement system."[74]

The report highlighted that "fragile" manufacturers suffered safety and funding issues which hampered their ability to meet the military's standards, and that consolidations in the early and mid 2010s in particular, amid a sharper post-2008 industry decline as budgets were further cut, had created several monopolies. This meant that the Pentagon often had only a single supplier for certain key parts which seriously undermined efficiency and prevented market forces from driving up performance and pushing down costs as they would if the market could support a large number of vendors to bid for each contract. Like almost every report on the state of the defense sector, the White House report underlined a severe shortage in skilled laborers such as engineers, software developers and tradesmen. This was a problem across the American industrial base, but its impacts in the defense sector had particularly serious implications.[75]

NDIA Vice President Wes Hallman stated regarding the report that the military industrial base of today is "not what the arsenal of democracy was going into World War II." Referring to the Boeing-Lockheed Martin duopoly in fighter aviation—the sector which had the greatest share of very large contracts—he stated that in the Cold War era "it took you more than two hands to count the number of companies that could produce a fighter jet, and now we're down to essentially two.[76] That's a big deal, and that's just one sector." NDIA president and chief executive Hawk Carlisle, a retired four-star Air Force general, stated in the aftermath of the report's release: "Reliance on single producers within the supply chain, dependence on unstable or unfriendly foreign suppliers for critical components, and misplaced presumption of continued preeminence of American military superiority are examples of findings that should be immediately addressed . . . Compounding these

risks, the report highlights a drain on talent that now flows toward Silicon Valley startups instead of defense-focused industries."[77]

Undersecretary of Defense for Acquisition, Technology, and Logistics Ashton B. Carter, who later served as defense secretary, referred to these skill sets in 2009 as "very rare kinds of skills that are not easily replicated in the commercial world and, if allowed to erode, would be difficult to rebuild." "Having the best defense industrial and technology base in the world is not a birthright," he stressed, highlighting that these were under particularly serious threat "in a globalizing and commercializing world." The fact that market forces and the tide of globalization strongly favored East Asian industry over that in the West boded ill for America's ability to retain a military advantage or even parity in the medium and long term.[78]

Disaster for American Defense Procurement

The serious issues affecting the American defense industry[79] that were raised in the late 2010s and early 2020s had in many cases been highlighted for decades, and were only worsening with time amid a broader trend toward deterioration of the country's industrial base. Heritage Foundation Senior Research Fellow in National Security Policy James Jay Carafano warned as early as August 2009 that under the new Obama administration it was unclear how Washington would be able to "sustain a defense industrial base" following reductions to expenditures in the wake of the financial crisis. He indicated that this was an issue which had been neglected since the Cold War, and which the Bush administration had hardly handled much better with some areas of the industry "already on life support when Obama took over." The new administration's policies notably accelerated this trend—"gutting America's defense industry" in the process. "America is returning to the 19th century, a world where it will be incapable of producing the instruments needed to defend itself. Secretary of Defense Robert Gates' policies are pumping steroids into the speed of that decline," he warned. Carafano was hardly the only one to warn of this trend, and the passage of time showed that his concerns were indeed well founded.[80]

Dr. Carafano's report claimed that Pentagon officials "seem to admit that the United States lacks the necessary industrial capacity to supply many important goods that the military needs. Indeed, Pentagon officials have opposed efforts to require preference for domestic suppliers over foreign sourcing in defense procurement, on the basis that many foreign products are superior in reliability and performance, while costing less than those made domestically." It further noted increasing "concerns about the viability of the US machine tool industry to supply the ultra-high precision tools needed to replace existing tools and meet future demand." "There is a tacit acceptance,"

it stressed, "that the United States lacks a sufficiently robust commercial industrial base to supply many vital products needed for maintaining a strong defense industrial base." It concluded: "the Pentagon's support for globalizing defense procurement not only reflects the growing inability of our industrial base to meet national security needs, but in itself contributes to the ongoing unraveling of the nation's overall industrial capacity."[81] This vicious cycle spanned out over several decades—the more the Pentagon outsourced abroad the more domestic industry declined, and the more it declined and became less competitive, the greater the incentive to outsource was.

As noted in 2010 by Deputy Chief of the Joint Enabling Command, US Joint Forces Command, Colonel Michael Cole, the problem facing the defense sector was not the disappearance of a handful of specialized items designed to meet narrow defense requirements, but the "eradication of US industry capability." Cole was among many to warn that the industrial base was increasingly unable to supply the military with manufactured parts and electronic components, and that attempts to reverse this trend continued to fail.[82]

Former analyst at the RAND Corporation and specialist in national security and manufacturing, Professor Michael Webber, opened his 2009 assessment of the state of the US industrial base, and the lack of action to remedy it, with the following analogy: "The optimist fell from a 10-story window; as he passed each bar, he shouted to his friends inside, 'I'm alright so far.'" Of sixteen individual defense manufacturing sectors, thirteen suffered from "significant erosion" from 2002 to 2007 without any signs of recovery, Webber highlighted, and this was "cause for concern to the overall health of the national innovation system that supports the military enterprises." He stressed that the level of decline was entirely unique in the history of the American defense sector, and that industries showing erosion were vital not only to defense but also to the wider economy and "the health of the national innovation system." Regarding the decline in R&D funding and loss of key skills he warned: "there is little investment in basic research and development or in advanced production processes. And there are fewer students enrolled in the science and engineering fields that support these industries. The country is losing a highly skilled workforce that cannot be easily retrained." These trends were particularly serious from 2001, and became much worse from 2008.[83]

Citing studies by the RAND Corporation, Webber noted that top tier of defense contractors such as Boeing and Lockheed Martin were focused much more on systems integration than on innovation while "pushing the burden of innovation lower into the supply chain." The smaller firms relied on to innovate, in turn, were the most vulnerable to being made unviable by the broader decline in the industry meaning the contraction of the industrial base

placed innovation key to modernization and competitiveness at particularly high risk. The former RAND analyst also highlighted that the defense sector's ability to innovate was impaired by its lack of a healthy support base, as so much of civilian industry had been outsourced overseas. "If the manufacturing support base no longer adequately serves the innovative companies, then their ability to be competitive is hindered and innovation does not move up the chain to the top-tier integrators. Consequently, the health of the entire innovation food chain, and thus the entire national innovation system and the defense industrial base, relies on the health of the foundation of the entire system: the manufacturing support base," he stated to this effect.[84]

In early 2011 *Air Force Magazine* reported: "procurement is outpaced by operations and maintenance spending. The number of major aerospace programs is down. Production line workers are old, and attracting talented young engineers to careers in the defense sector is challenging. Is it crunch time for the aerospace industrial base? A wide consensus says yes." The events of the following decade would largely prove this to be correct. As a study by the Brookings Institution observed at the time: "there is growing concern about the future of American defense industry as well as the national security industrial and scientific base." US Strategic Command General Claude Robert Kehler stated to much the same effect: "Since the space age began, we have rarely been so reliant on so few industrial suppliers."[85] President of Boeing's Phantom Works, Darryl Davis, stated regarding this trend that year: "For the first time in industry history, there are currently no new, ongoing US military, manned, fixed-wing development programs." The highly concerning observations from 2011 had become much more serious by 2021.[86]

Speaking to former Secretary of State Mike Pompeo in April 2021, German-American tech billionaire Peter Thiel observed to similar effect in 2021 that market consolidation had made the defense sector much less competitive and compounded the effects of post-Cold War budget cuts. He stated: "what happened in '89 after the Cold War ended, was there was a shrinking of military budgets, but there was also an incredible consolidation of the defense industry, and the consolidation actually meant the money was spent less efficiently—especially with respect to R&D. And so we spent less money and [with] less efficiency, and so there was some massive decline in the effectiveness of the system in the 90s."[87] Although the Trump administration's surge in funding for the military was widely seen to have slowed the trend toward decline, it was far from sufficient to reverse or even pause it. As part of a decades-long trend, it would require very radical change to reverse and increasingly appeared to be irreversible unless much broader issues with the US economy were addressed.

A smaller defense sector more concentrated in the hands of a few major firms led to what some have classified as an oligopoly—a market situation

that stifles efficiency and competition. This often reached the state of a full monopoly in the cases of many defense products as a single firm became the sole source. Dozens of reports to this effect were released by a range of sources, and with growing frequency, in particular during the 2010s when the consequences of decline became increasingly evident in new generations of weapons programs. The Department of Defense (DoD) released a report in 2018 on the defense industry highlighting that for several products there were only two or even one domestic companies that produced them—and in some cases absolutely none as local manufacturing had declined which forced the Pentagon to look abroad.[88] More concerning still, in 2019 a Government Accountability Office report concluded that of 183 contracts for major weapons systems examined, 67 percent had no competitive bidding process which removed the incentive for firms to improve their prices or their quality. This was the ideal market situation to stifle innovation and development and to drive up costs.[89] In the Spring of 2020 *Foreign Affairs* referred to this as "the curse of monopoly capitalism that already affects the country's over consolidated defense sector—causing higher costs, lower quality, reduced innovation, and even corruption and fraud." It stressed that these issues with the defense sector would continue to worsen based on prevailing trajectories.[90]

The decline in the American defense sector in the post-Cold War years had very tangible consequences, with all of the country's major weapons programs almost without exception facing serious performance issues, cost overruns and delays far in excess of Cold War era programs when the industrial base had been much healthier and more robust. Perhaps the most iconic example was the world's largest ever weapons program, the F-35 stealth fighter, which at the latest estimates was expected to cost over $1.7 trillion.[91] By the beginning of 2014, eleven months before the fighter's entry into service, the program was already $163 billion over budget and a full seven years behind schedule.[92] It would be several more years, however, before the F-35 would be ready for medium or high intensity combat due to hundreds of design defects.[93] The number of flaws in the aircraft were counted at 873 in January 2020[94] and shown in March to still be increasing as more design flaws continued to be discovered while efforts to fix existing ones remained slow.[95] The F-35's development costs were estimated at $55.5 billion,[96] compared to just $4.4 billion for its Chinese rival the J-20,[97] and although the American program did produce three separate variants with different ways of taking off and landing, it also benefited considerably from prior R&D into the F-117 and the F-22 stealth fighter programs which pioneered many of its key technologies. As China's first ever stealth fighter, the burden on the J-20 for research and development was considerably higher in this regard making its much lower development cost all the more outstanding.

The F-35's underperformance was attested to by a number of sources from military think tanks such as NSN[98] and RAND,[99] to organizations such as the Project on Government Oversight,[100] and individuals such as the Pentagon's chief weapons tester Michael Gilmore[101] and Marine Captain Dan Grazier.[102] Senate Armed Services Committee Chairman John McCain referred to the F-35 as "a textbook example" of the country's "broken defense acquisition system," and as "both a scandal and a tragedy with respect to cost, schedule and performance."[103] More bluntly, Defense Secretary Christopher C. Miller stated in 2020 that "the F-35 is a piece of ****," while his predecessor Patrick Shanahan referred to the troubled fighter in 2019 as "f—ed up."[104]An inquiry by the Pentagon's Office of the Inspector General found that Shanahan's criticisms of the F-35 "were consistent with other comments about problems in the F-35 program made by other senior DoD officials."[105] While several volumes could be written on how the F-35 program exposed the state of the American defense sector and its declining ability to compete with high level challengers, for the sake of brevity this will not be explored in detail here. Despite the program being considered 'too big to fail,' and the sheer amount of sunk costs and lack of alternatives pressing the Pentagon to continue to invest, signs that the military would finally begin to cut its losses and sharply cut F-35 orders began to emerge in 2020. Under proposed plans for cuts, the troubled stealth fighters would be replaced in the Air Force's modernization plans by something similar to an improved version of the F-16—a 1970s fighter design which would have been flying for over fifty years when the first new variants were delivered and would be over eighty years old by the time they were retired.[106] The fact that a return to F-16 acquisitions, or something very similar to it, was even considered, underlined the extent and severity of the problem.

America's only other post-Cold War fighter, the F-22 Raptor, was similarly problematic. The fighter had its capabilities seriously watered down with several key systems removed,[107] was several years late, 56 percent over budget—or much more if considering R&D costs,[108] and had far higher operational costs than contracts originally stipulated. This was a major factor in the decision to cancel 75 percent of planned production aircraft, with impractical and excessive maintenance needs resulting in very poor mission capable rates well below those of either Cold War era American fighters or twenty-first century foreign competitors.[109] One of Air Force report highlighted "maintenance troubles" and "unexpected shortcomings" with serviceability.[110] Issues with breakdowns, poisonous effects on pilots' lungs known as 'Raptor Cough,'[111] and problematic avionics and computer architecture,[112] among several others, sharpened the contrast to its successful Cold War era predecessors the F-4 and F-15. Reflecting its failure to succeed the F-15, the F-22 saw production terminated less than six years after entering service—where by contrast the

F-15 is still in production and on order by the US Air Force today almost fifty years after it entered service in 1975. The new much more expensive aircraft had a shorter range, lower availability rates, lower reliability, much poorer versatility, much greater difficulty incorporating upgrades, and many more performance issues than the F-15—while failing to deliver improved performance in those areas in which the Air Force assessed the F-15 as most deficient.[113] In May 2021 longstanding suspicions that the Air Force would condemn the F-22 to an early retirement were confirmed, with the fighter set to be outlasted in service by several decades by the F-15 and other Cold War-era combat jet designs which proved much less troublesome.[114]

Debilitating issues with the F-35 and F-22 programs, which led both to fall short of being viable replacements for their Cold War era predecessors, represented only a part of a much broader trend not only in US military aviation but in the entire post-Cold War defense sector. The aforementioned issues with new surface ship designs provide further notable examples. For the sake of brevity the full extent of performance issues with these programs, each of which could fill several chapters, will not be given here. The weapons programs already mentioned in this chapter, which are the largest pursued by the US military since the Cold War's end, illustrate the extent of the defense sector's decline and bear a stark contrast to its much better performance when the US maintained a vibrant industrial base during the Cold War. This also contrast sharply with how smoothly and unproblematically China in particular has been able to roll out a range of new weapons systems from aircraft carriers and destroyers to stealth fighters.

The decline in America's military industrial base is not just a significant phenomenon in and of itself, particularly at a time of rising tensions with China, but it also serves as a strong indicator of a much broader trend in the US economy and by extension in the large majority of economies across the Western world. With military production having been the most protected sector of American industry from outsourcing abroad precisely because of its importance to national security, a far faster and sharper decline than that seen in the military industrial base could be observed in the country's relatively unprotected civilian industrial base. A broader trend toward American industrial decline could not be prevented from affecting military industries, despite the Pentagon and Capitol Hill on many occasions identifying the problem and warning of its consequences. Properly addressing defense sector decline would require the US to reverse the trend toward offshoring its civilian manufacturing, which had become effectively impossible without destroying its ability to compete.

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Chapter 9

The World Economy Split in Two

America's Response to Competitive Disadvantage

AMERICA'S INDUSTRIAL DECLINE

Beyond decline in the defense industry and its far-reaching consequences for security, America's geopolitical position has been seriously undermined by a parallel and more serious decline in the civilian industrial base. While government intervention limited the rate of offshoring and contraction of the defense industry, civilian industries generally left to market forces contracted significantly more quickly which had profound implications for the US's ability to compete with China economically or in high tech.

Manufacturing's share of American Gross Domestic Product had fallen steadily from the late 1960s, with the rate accelerating particularly sharply from the turn of the century and again following the 2008 financial crisis.[1] In 2019 Heritage Foundation Senior Research Fellow in national security policy, Dr. James Jay Carafano, observed regarding the state of American industry and its sharp decline over the preceding decade:

> The signs of industrial decline reflected by major domestic and global economic indicators, the threat to innovation and the loss of America's technology edge, and the shrinking skilled workforce and loss of science, engineering and manufacturing know-how . . . several key indicators of domestic economic performance and global competitiveness, when taken together, do provide strong evidence that America's manufacturing base has been greatly weakened over the last decade.[2]

Editor of *Manufacturing & Technology News* Richard McCormack, a leading expert cited by the US-China Economic and Security Review Commission among others, lamented in 2009 "an infrastructure that was rapidly deteriorating, with bridges and levies falling to the mighty Mississippi River," and to "a severely weakened industrial base." This left the country "without industry generating good jobs, wealth and the funding needed for research and development." Among the dozens of examples cited, some of the American industries left struggling after losing dominant positions over the previous fifteen years were "semiconductors, machine tools, printed circuit boards, consumer electronics, auto parts, appliances, furniture, clothing, telecommunications equipment, home furnishing and many others."[3]

Remaining manufacturing, McCormack observed, was "mostly in areas subject to strict government regulations and that receive heavy federal R&D investment" which slowed the rate of offshoring, most notably defense and the medical industry. As previously mentioned with defense, the ability of these industries to compete in the long term in effective isolation from a broader civilian industrial base was highly questionable. McCormack warned regarding this: "Today, the United States can produce a stealth bomber, but it can't produce a pair of shoes. The United States government and its military strategic thinkers have forgotten a basic ancient military principle: Without industry a country cannot maintain an army."[4] Although exaggerated, this statement was broadly true particularly as the trend toward dual civilian and military uses of high tech continued to grow and civilian R&D became increasingly vital for military modernization. Industrial decline, and resulting decline in innovation, were transforming America's economic and military standing in the world. This was widely alluded to by analysts, with senior fellow at the Carnegie Asia Program James L. Schoff warning that "qualitative military advantages" of the US "could easily be lost if they cannot compete successfully with China in the innovation race."[5]

By the end of the 2000s, in the wake of the financial crisis, the poor state of US industry was increasingly evident with decline having accelerated over the past decade. The following are some examples: The printed circuit board industry shrank from $11 billion in 2000 to $4 billion in 2007 despite considerable growth in the industry globally,[6] with the share of global production by US manufacturers falling from 26 percent in 2000 to under 8 percent. This industry was particularly vital for high-tech innovation due to how widely its products were used. Where Chinese steel production grew from 124 million to 500 million tons from 1999 to 2008, the US steel industry's output fell from 97.4 to 91.5 million tons in the same period.[7] The US furniture industry lost at least 60 percent of its domestic production capacity from 2000 to 2008 alone, with 270 major factories closed in that time and the market share of imported wood furniture rising from 38 percent to 70 percent.[8] The

US automobile industry also saw continued decline in its market share. With machine tools serving as the backbone of any industrial economy, and thus as a useful indicator of the overall state of industry, machine tool consumption in the US in 2007 stood at $6 billion—30 percent lower than it had been in 1998. Chinese machine tool consumption had increased by 600 percent from $2.2 billion to $15.4 billion during that period.[9] These trends only grew more extreme after 2008.

McCormack had attributed industrial decline to both poor policy decisions in Washington and to "a global economic system that continues to be stacked against US-based producers."[10] The latter was largely a result of both the aforementioned limitations on and deep inefficiencies of American industry, and the strength of the US dollar which had a much lower purchasing power in America itself relative to what it had overseas. Taking labor costs as an example, the incentive for firms to offshore production from the US and more generally away from the Western world were tremendous, with the *Sandford Social Innovation Review* in 2019 providing the following case as an example:

> A rather weird story about 'Bob' (not his real name) at Verizon illustrates this global pressure [toward outsourcing overseas]. Bob was a computer programmer, seen daily staring diligently at his computer monitor. Then, in 2013, Verizon discovered that Bob was mostly just surfing the Internet. How was he able to do his work, which the company consistently described as the 'best in the building?' It turned out that Bob had outsourced his own job to a Chinese firm, paying them less than a fifth of his six-figure Verizon salary. Bob was quickly terminated, and it appears he used the same scam with other employers.[11]

The *Review* concluded: "his story shows how global wage differentials for technical work will pervade corporate decisions."[12] If the jobs of 'Bob' and others like him could be outsourced directly, the firms employing them could become significantly more efficient. As a result globalization and a high tolerance in Washington and other Western capitals for offshoring was a disaster for Western manufacturing. In China's case, however, the favorable discrepancy in purchasing power was only part of the reason why it gained substantial foreign investment and offshored jobs, with the country's large pool of skilled and educated workers, effective organization, reliable infrastructure, stable political system, and excellent cultural work ethic all contributing heavily. Other countries where the dollar enjoyed a high purchasing power, in many cases much higher than that in China, such as India, Pakistan, Iran, Indonesia, Egypt and Mexico enjoyed no comparable investment booms or benefits from outsourcing. This allowed China to continue to be a very popular destination for outsourcing despite a fast rise in wages in the 2000s and

2010s. Even as the gap between Chinese and Western wages became much narrower, investment in China particularly in manufacturing was still much more cost effective. China's ruling party had shaped an economy which global markets determined was in many ways the most efficient in the world, and with market forces strongly on its side and Western firms and global finance seeking to maximize profits, and holding considerable sway over policy, Washington was hardly able to move against the trend.

FREE MARKETS CHOSE CHINA—SO AMERICA TURNED AWAY FROM FREE MARKETS

Trends toward an American industrial decline continued through the 2010s and into the Donald Trump administration, under which growing hostility toward and tensions with Beijing led Washington to much pay closer attention to the state of its industrial base than it had in decades. The wisdom of adhering to a neoliberal system and allowing market forces to shape the economy with minimal government intervention was increasingly questioned as a growing consensus emerged that a laissez faire approach had effectively ended the era of American primacy. The serious discrepancy in the competitiveness and efficiency of Chinese and American industry, and by then the fast-emerging technological primacy of the former, fueled growing support in Washington for greater government intervention to subsidize sectors of civilian economy deemed strategically important and at risk of failing. Although the Trump administration's trade war on China initiated in 2018 was widely seen to be an abject failure if not counterproductive,[13] it marked a turning point in support for the idea that although markets had deemed China the most efficient location for major supply chains, Washington needed to intervene against this trend to move manufacturing back to the US if not at least out of China.[14]

A new bill proposed in June 2020 placed a strong emphasis on domestic manufacturing including contributing over $22.8 billion to the semiconductor industry under a new trust fund for federal grants to encourage emerging producers. The fund could receive as much as $10 billion a year, and was financed by new import tariffs on Chinese goods. Officials in the Departments of State and Commerce had created a standard package of incentives that could be offered to attract semiconductor producers to manufacture in the US. The *New York Times* referred to months-long efforts by the Departments of Defense, State and Commerce "to woo chip makers including Intel, Samsung and Taiwan Semiconductor Manufacturing Company to expand their manufacturing footprint in the United States."[15] Due to aforementioned deficiencies in the American industrial base, costs of manufacturing in the US

and shifting away from a reliance on Northeast Asian industry were widely predicted to be far from feasible.[16]

Government intervention in the chip industry came as part of a broader effort by the state to boost high tech, and followed a bill introduced in late May to increase funding by $100 billion over five years for the National Science Foundation focusing on strategically critical areas including artificial intelligence, robotics and advanced manufacturing. A second bill was at the time expected to be tabled by the end of the year to support the chip industry. Chair of the Senate Democratic Caucus Chuck Schumer stated to this effect: "One of the biggest weaknesses in the American economy is the decline of our scientific and innovation industrial base, and we must invest in academic institutions and industries to rebuild it. There's bipartisan support to do so and it's growing each day."[17] The unprecedented nature of these efforts reflected the seriousness of the situation, with the risk of an end to centuries of Western technological primacy and decades of US primacy being a real possibility.

Giving important insight into the rationale among lawmakers from both parties for supporting government intervention, Republican Senator Marco Rubio stated in August: "Ultimately, capitalism is the best economic model. It will always yield the most efficient outcome. But there are times where the most efficient outcome is not the best outcome for America."[18] This was effectively an admission that a more competitive China had outperformed the US in the free-market system which Washington had long advocated should be adopted universally. Senator Rubio further highlighted that US businesses weren't investing as much as they used to on new equipment and manufacturing, blaming pressure from the financial sector to improve efficiency, reduce costs and return more money to shareholders. This led firms to reduce spending on equipment and factories domestically and increasingly offshore their manufacturing which improved their efficiency but eroded the American industrial base. The result, Rubio noted, was that US industry had shrunk considerably which over time undermined American innovation.[19] As argued by Oren Cass, a former policy expert at the right-leaning Manhattan Institute think tank which advised Rubio on industrial policy, it was often the people who made things who had the best ideas for new products. This was a rationale which largely drove support for government intervention to revive manufacturing as a means of fuelling innovation.[20]

Rubio was hardly alone among prominent Republicans who had joined the Democratic Party's push for state investment to boost competitiveness of major industries in response to Chinese competition. Senator Todd C. Young and Representative Mike Gallagher, both Republicans, notably proposed in May 2020 investment of $10 billion to establish regional tech hubs to boost manufacturing. This was referred to in official reports as the 'Endless Frontier Act to Bolster US Tech Leadership and Combat China.'[21]

In June 2021 Republican Senator Tom Cotton of Arkansas sponsored the subsidies-for-semiconductors legislation which stipulated investment of tens of billions of dollars by the federal government to boost the semiconductor industry.[22] US lawmakers from both parties supported the legislation on the basis that it would counter Chinese advances in the field, as mainland firms increasingly threatened to follow in the footsteps of those in South Korea and Taiwan and overtake those in the US. China had already surpassed America quantitatively in semiconductor production with its share of global output from 1990 to 2021 having risen to 1 percent to 15 percent while the US share fell from 37 percent to 12 percent.[23] Where government-led industrial plans were generally viewed highly negatively in America, Cotton's legislation represented a growing trend toward bipartisan support for government intervention.

As the *New York Times* noted, such efforts "reflect a shifting consensus in Washington, as lawmakers look to more expansive government intervention in private markets to help American firms compete. That includes Republicans, who have long criticized government-led industrial plans as inefficient and redolent of communism but have watched with dismay as such efforts in China have allowed it to dominate industries from steel and solar panels to shipbuilding."[24] According to Rob Atkinson, president of the Information Technology and Innovation Foundation industrial policy think tank, no Republican would have supported that kind of legislation a decade ago—"Not in a million years. They would have been pilloried for picking winners." The extreme nature of the shift, with conservative Republicans suddenly leading calls for state intervention to 'pick winners' in the tech sector, reflected the perceived imminence and seriousness of the threat to US dominance.[25]

Analysts quoted by the *Washington Post* highlighted that in response to China's gradual economic and technological surpassing of the US under a partnership of the public and private sectors, Republicans were "abandoning free-market orthodoxy" to counter "an unprecedented challenge to US power—China."[26] It remained uncertain, however, how far Washington would deviate from its longstanding ideological commitment to free markets and laissez faire economics if its position of global leadership was threatened by a demonstrably more competitive rival economy built around extensive state planning. The *New York Times* at the time described the Trump administration as having "rejected traditional Republican support of free trade in favor of a more managed approach to compete with China," highlighting that it had a "plan to use trade and technology policies to return manufacturing to American shores."[27]

The shift away from free-market ideology in response to Chinese competition could also be seen in the defense sector. One of the most drastic

indications of this was a statement by the head of acquisitions for the US Air Force, Dr. William Roper, in July 2020 that a deteriorating industrial base and a struggle to maintain competitiveness with near-peer military rivals could leave nationalization of parts of the military aviation industry as the best course of action. He warned:

> Technical talent is at a premium. If the design opportunities are so few and far between that joining a defense company means you may get to design one thing in your career . . . and that's if you're lucky—that that talent will go elsewhere into commercial innovation where the opportunities are more plentiful . . . If our industrial base collapses any more, we'll have to nationalize advanced aviation and maybe other parts of the Air Force that currently are competitive.

Roper highlighted that a nationalized defense sector would allow the Air Force to procure aircraft more cheaply, calling attention to the significant inefficiencies in ownership, sustainment and modernization costs under the existing private system and concluding that "everything has to change." He further stated his surprise that the America's declining military industrial base was not generally gaining sufficient attention despite the seriousness of the situation. "I think it's really important that we find a new model where there are no big winners and no big losers, but continual competition," he concluded, highlighting the emergence of an oligopoly as the number of defense producers continued to contract.[28]

Roper was hardly alone in calling attention to the potential need for greater government intervention and a degree of nationalization. Army Chief of Staff Mark Milley, for one, highlighted that the state run defense industries of China and even Russia could produce armaments far more cost effectively which helped these countries to heavily compensate for their much smaller defense budgets relative to the United States.[29] Subsequent calls to nationalize part of what may well be the most lucrative industry in the Western world, arms and specifically military aviation, were unlikely to sit well with established defense sector interests despite the possible benefits for national security. Vice President of analysis at the Teal Group aviation consulting firm Richard Aboulafia, for one, noted that the prospect of nationalizing America's military aviation sector was "an admission that they have failed miserably." He called for "at the very least, a public-private partnership—nationalization being, kind of the land of the lost."[30]

Beyond defense and semiconductors, significantly broader steps were taken by the US government to offer direct support to ailing sectors of the domestic economy which were considered strategically critical to counter China. Chair of NSCAI and of the Defense Innovation Board, Eric Schmidt, stressed that the US tech sector was likely to fall behind China unless it

received considerable federal government support. Publishing an opinion piece in February 2020, its opening line warned: "We can't win the technology wars without the federal government's help." He stated regarding the need for a much more interventionist government approach to research and development:

> In recent years, Americans—Silicon Valley leaders included—have put too much faith in the private sector to ensure US global leadership in new technology. Now we are in a technology competition with China that has profound ramifications for our economy and defense—a reality I have come to appreciate as chairman of two government panels on innovation and national security. The government needs to get back in the game in a serious way.[31]

Citing AI and 5G in particular, Schmidt noted that "important trends are not in our favor," warning that China: "has almost twice as many supercomputers and about 15 times as many deployed 5G base stations as the United States. If current trends continue, China's overall investments in research and development are expected to surpass those of the United States within 10 years." These estimates for investments did not account for the difference in purchasing power, which would otherwise show a significantly greater Chinese advantage. Schmitt concluded: "Unless these trends change, in the 2030s we will be competing with a country that has a bigger economy, more research and development investments, better research, wider deployment of new technologies and stronger computing infrastructure."[32]

Schmidt notably equated a loss of American primacy in fields such as AI with threats to international stability, highlighting that Western-led world order depended on continued Western dominance of key technologies. He thus called for "unprecedented partnerships between government and industry" and "bold, bipartisan initiative" to "extend our country's technology advantage," including government support to develop alternative 5G markets which could challenge Huawei. The comprehensive government-led national strategy for technological development he laid out somewhat resembled those of the Chinese government under initiatives such as Made in China 2025, in effect calling for America to abandon its private sector led approach in order to remain competitive. Schmidt tied dominance in key technologies to the emerging discourse regarding ideological struggle, concluding:

> Ultimately, the Chinese are competing to become the world's leading innovators, and the United States is not playing to win . . . Success matters far more than our companies' bottom lines and our military's battlefield edge. We must show that these new technologies can advance individual liberty and strengthen free societies. For the American model to win, the American government must lead.[33]

While the government moved to increase support for the private sector in key industries, America's very different political and economic ideologies and systems effectively ruled out anything approaching the level of long-term planning and public-private sector cooperation seen in China.[34] The US' ability to transition away from an economic system which had been entrenched for decades, and to be able to afford the massive support needed to prop up industries such as semiconductors which would otherwise be too inefficient to compete against East Asian rivals, were both highly questionable. Although some of the proposals for government intervention in the economy appeared radical, they were far from likely to be sufficient to reverse the overwhelming trend toward US decline.

THE WORLD ECONOMY SPLIT IN TWO

Facing trends which strongly portended Chinese ascent and US and Western decline in their positions both in the world economy and in global high tech, the Trump administration initiated moves to reverse the tide of globalization and isolate the US and as much of the world as possible from China. The term bifurcation—the division of something into two branches or parts—was increasingly used to describe Washington's objective of carving out a 'Western half' of global high tech and international trade in which a more competitive China would be made to face arbitrary restrictions. With integration of countries' economies and their tech sectors occurring in parallel, bifurcation of both was also pursued by the Trump administration simultaneously.

The *Washington Post* may have coined the best description for inducing bifurcation—"building a moat around Western technologies" as well as around Western markets, diving the world between countries which joined the US in isolating themselves and those which did not.[35] Moves toward preventing Huawei, the undisputed global leader in 5G, from bidding for contracts in the US and in as many others states as Washington could bring into the fold, was but one of the first steps in this direction. Global 5G markets were to an extent split in two—between those which allowed the most competitive firms to bid and those which allowed only those considered politically sound for Western interests to do so. Such policies threatened to reshape the formerly globalized world tech sector and economy.

As noted in the title of a *Wall Street Journal* article in December 2018: "Trump Didn't Kill the Global Trade System. He Split It in Two." It highlighted that the administration was "presiding over its realignment into two distinct systems," with the extent to which it was willing to decouple from China and the degree to which it could make its allies follow suit both in question.[36] A prominent *Financial Times* article six months later, titled:

"US-China trade war risks global technology split," was one of many to warn of the same trends.[37] Singaporean Prime Minister Lee Hsien Loong warned later that month that while Washington's trade war and tech war against China would not lead to a global financial crisis, it divided the global economy with much more serious consequences. He stated to this effect: "They are going to have a bifurcation of technology, of markets, of trust. I think that is a very bad consequence for the world. That will be a structural thing, which will last for many decades, and that is even more serious than a financial crisis."[38]

Regarding the consequences of a US-driven division of the global economy, Prime Minister Lee noted that it had "hurt global business and consumer confidence, leading to a decline in global trade and investment, and will eventually affect jobs. Longer term, the greater risk is a split in the supply chains and the technology stack, after many years of working in an interconnected world." He concluded "Globalisation has resulted in progress and prosperity in terms of technology, breakthroughs and sharing knowledge among humankind. The alternative will be a less prosperous, more troubled world."[39]

CNBC in September 2019 highlighted that increasingly radical policies could result in a "split world order," citing experts who emphasized "a real risk" that the world would be split into two separate geopolitical and economic blocs as a result.[40] *Bloomberg* similarly warned that America's tech war on China was fomenting "the process of creating a digital iron curtain that separates the world into two distinct, mutually exclusive technological spheres."[41] A separate article by the paper elaborated:

> A slower-moving, but more significant divide, is likely to form between nations as this digital Iron Curtain falls. Having mutually exclusive technological spheres doesn't simply mean supply chains will mirror each other on different continents. Rather, for countries around the world, it means that every business and investment decision becomes a political one . . . if a nation agrees to install Chinese networks or infrastructure, there's an increasing chance it will be cut off from US products under the guise of American national security . . . Such decisions will need to be made around the world. They won't be rushed, and probably won't be come in clear declarative speeches at a podium. Instead they'll be made in the meeting rooms of bureaucratic institutions, over the table at cabinet meetings, and in foreign embassies where the carpets will be worn thin by a stampede of government and non-government lobbyists. Just as the world was divided along military lines 70 years ago, the digital Iron Curtain will force political leaders to decide whether they're Team China or Team America.[42]

Splitting the economies of the US, the broader Western world, and if possible Western-aligned third world countries, from China, was for many a goal in and of itself rather than an unintended consequence of the trade and tech wars. "To a large extent, the current race to decouple is the fruit of two decades of

steadily growing Chinese economic might," *Foreign Policy* observed in May 2020 regarding the growing trend toward bifurcation, elaborating:

> For the more hawkish members of the Trump administration, undoing 40 years of ever-closer economic relations with China and rolling back US reliance on Chinese factories, firms, and investment was always the end game of the endless trade war . . . Now, lawmakers and administration officials are mulling a raft of measures to cleave parts of the two largest economies in the world: Bans on a wide variety of sensitive exports, additional tariffs on Chinese goods, forced reshoring of US companies, even pulling out of the World Trade Organization altogether, which is seen by some as facilitating China's so-called economic imperialism…[43]

The magazine compared decoupling to "the sudden sundering of the first huge wave of globalization in 1914" when the deeply intertwined economies of Britain and Germany went to war. "The looming reshaping of the sinews of the world economy will have untold implications, from tearing up business models to remaking entire industries," it warned.[44] *Foreign Affairs* the following month slammed Washington's moves toward bifurcation, stating in the title of a prominent article: "it isn't just perilous, its impossible." The Chinese economy is "not a discrete organism that can easily be separated from the global economy but rather a Siamese twin, connected by nervous tissue, common organs, and a shared circulatory system," the journal stressed. It was one of several sources to predict that it was much more likely that the US, rather than China, would see its products phased out of supply chains and its economy isolated if it held to such a position.[45]

As part of broader efforts toward bifurcation the Trump administration began to press firms from Western-aligned states to relocate their businesses away from China. This effectively placed Washington's goals against the strong market incentives that drew firms to operate in the country. Although a politically motivated division of the global economy had the potential to benefit some Western firms, such as Ericsson and Nokia which captured of 5G markets with an effective duopoly wherever Chinese competition was banned,[46] bifurcation faced considerable resistance from the bulk of private sector interests.[47] As observed by managing director of the China Beige Book, a platform that analysed data on China's economy for investors, Shehzad H. Qazi:

> Companies are going to be incredibly resistant to anything that hurts their share price. We're not going to see, for example, Nike move all its production back to the United States and have their shoes and athletic wear being produced here, just because from a cost standpoint that makes absolutely no sense. I don't think there is any amount of tax incentives that could be provided that would be

> palatable enough to make that shift happen. There are going to be some industries where it's going to be virtually impossible no matter what.[48]

The trend toward private sector resistance against bifurcation was strongly reflected in the results of a 2020 business survey by the American Chamber of Commerce in Shanghai, an organization known as the 'Voice of American Business' in China that promoted US firms in the country and included members from over 1,500 companies. President of the chamber Ker Gibbs described US businesses in China as "so disturbed to see all the calls for decoupling . . . a lot of members do feel a bit of whiplash from the past three-and-a-half years and want to see a more long-term strategy." He cited the possibility of a White House ban on American firms using the Chinese media application WeChat as an example of Washington harming American businesses through its pursuit of bifurcation, stating: "we have pins and needles right now. If American businesses in China have to stop using WeChat, this would be devastating." Almost two-thirds of respondents to the survey said US-China tensions were their greatest concern—the first time bilateral relations led the poll—with the second greatest being competition from local firms at 58 percent.[49]

The COVID-19 crisis only solidified US firms' resolve to remain in China due to the significant discrepancy between how well the country and most of the rest of the world handled the pandemic, with a significant rise in the number of firms planning no change in production allocation compared to 2019. 78.2 percent of firms saw higher profits in 2019 than the preceding year, with 32.5 percent seeing greater revenues in 2020 compared to 2019, which bore stark contrast to almost all other major markets.[50]

The financial sector was similarly caught between the attractiveness of doing business in China and measures by Washington pressing it to withdraw. As *The Economist* noted in September 2020, financial firms were extremely cautious to comment on how geopolitical tensions affected their strategies in China. "We don't want to end up in a Trump tweet," one stated, as they feared a public shaming for being unpatriotic and pursuing profits over Washington's interests. "President Donald Trump's administration wants global financiers to pull back from China. But China is enticing them in, creating opportunities that few had expected to come so quickly, if ever. It created a disconnect between the political and financial realms," the British magazine noted.[51] Indeed, the *Wall Street Journal* three months later described the American financial sector as China's "one powerful friend left in the US," with Wall Street given opportunities to expand in the country which reined in Washington's push toward bifurcation.[52] China was providing such incentives while at the same time imposing new regulations to make its financial markets safer in areas of possible vulnerability.[53]

The economic policies made in both Beijing and Washington over decades had aligned market forces against bifurcation. This not only made a repatriation of industry and high tech to American shores on any significant scale effectively untenable, but also provided a strong incentive for firms to resist moves toward decoupling. As *The Economist* concluded: "Despite discussions of a new Cold War, there are reasons to believe that coupling, not decoupling, will remain the best description of Sino-US financial ties."[54]

Among a number of measures considered in Washington to increase both pressure and incentives for firms to leave China, the concept of an 'Economic Prosperity Network' of Western-aligned countries gained momentum under the Trump administration. It aimed to incentivize firms to partner with and invest in countries which had the Western-favored political affiliations rather than China, with such affiliations being prerequisites for membership of the network. It was hoped that as many of the non-Western prospective member countries such as India were still developing and had low wages, they would present a more viable path to offshoring from China than a reshoring to the West could. As noted by *Foreign Policy*: "If a US manufacturing company can't move jobs from China back to the United States, for example, it could at least move those jobs to another more US-friendly country, such as Vietnam or India." It referred to this process as the "deliberate dismantling—and eventual re-creation elsewhere—of some of the sprawling cross-border supply chains that have defined globalization and especially the US-China relationship in recent decades."[55]

Several officials supported taking this to extremes in the waning months of the Trump administration.[56] Actions proposed ranged from legislative moves toward withdrawing from the World Trade Organization,[57] presumably to replace it with an organization which gave favorable treatment to Western-aligned states, to defaulting on the $1.063 trillion of government debt held by the Chinese mainland specifically (Hong Kong and Taiwan between them held $450 billion more).[58] The possibility of a default was raised by a number of analysts, among them the former Governor of the Bank of England Mervyn King.[59] The damage this would do to the US economy, however, as Washington spent well beyond its means and relied heavily on other countries servicing its budget deficits, was generally seen to be sufficient to deter such action. A default would set a very dangerous precedent and risked significantly reducing foreign interest in buying American debt in future. China's debt holdings represented a mutual vulnerability which obstructed bifurcation, and while a sudden Chinese sale of its treasury bonds could quickly collapse their value by triggering a sell-off in the bond market this would also do significant harm to the Chinese economy primarily by threatening its exports to America. Treasury bonds represented just one example of Sino-US interdependence strongly deterring both sides from pursuing

escalatory measures, as Washington was as much deterred from cancelling its debt to China as Beijing was of suddenly selling its debt holdings.[60]

Multiple factors which deterred Washington from pressing too far with economic decoupling ranged from the lack of access to rare earth minerals, the global production of which was overwhelmingly in China, to an expected slump in Chinese demand for American primary goods—the most often cited example being soybeans. Worsening economic ties with Australia, which was perhaps the only country to take a harder line against Beijing, provided an opening for China to strengthen its economic integration with and leverage over the US by buying more American primary goods such as cotton, timber and coal to replace those it had sourced from Australia.[61]

Washington had options for further escalation including delisting Chinese firms from US stock exchanges which was highlighted as a possibility both in Trump's final year and in Biden's first.[62] The Defense Production Act and the International Emergency Economic Powers Act, which allowed the government to force the private sector to make production decisions that benefited the national interest, provided many further extreme possibilities. The 'nuclear option' in the push for bifurcation would be to block China's US dollar payments system either by ordering banks accordingly or by lobbying the Belgium-based inter-bank communication system SWIFT, which was used for most cross-border transfers, to block China-based users. Much as with treasury bonds however, all these steps were effectively deterred by high levels of economic integration with fallout potentially harming the US and Western economies more than China itself. As the head of the Chinese economy at the Macquarie Group in Hong Kong, Larry Hu, observed regarding China's moves to deter American escalation: "You have to create a situation where your counterpart has more to lose."[63] As *The Economist* observed, any extreme escalation by Washington: "would lead to a collapse in international trade, massively disrupt supply chains and, most likely, deepen the global recession. The fact that US policymakers must consider such consequences is an argument in favor of China's bonding strategy."[64] Washington thus pursued only smaller less radical steps toward decoupling such as banning of federal retirement funds from investing in Chinese stocks in early May 2020,[65] and six months later banning any company the White House deemed to be aiding[66] China's military.[67]

AGAINST THE TIDE OF GLOBALISATION: DIGGING A MOAT AROUND WESTERN HIGH TECH

One of the most vocal proponents of bifurcation of global high tech was the China Strategy Group (CSG) think tank, which in late 2020 published report

titled 'Asymmetric Competition: A Strategy for China & Technology.' The report strongly called for Western governments to work to divide global high tech in two. Like many similar proposals, it advocated engineering this division primarily along ideological lines to bring together countries with Westernized political systems, with some countries with different systems such as communist Vietnam permitted to join to further China's isolation. CSG was formed in July 2020 by influential US tech practitioners and policy researchers, and was conceived and founded by a leading advocate of the need for continued Western supremacy in high-tech—Eric Schmidt. It was co-chaired by Jared Cohen, the aforementioned former Google Ideas director and senior CFR fellow who had voiced particularly radical views about the use of technology to promote Western ideology and interests overseas (see chapter seven). Among other prominent members were Richard Fontaine, the CEO of the Centre for a New American Security, whose co-founder Kurt Campbell would occupy a top position on the Biden administration's National Security Council, and Liz Economy, CFR's leading China scholar. CSG's purpose was to tackle "the most difficult questions regarding US competitiveness with China on technology," and it consistently led calls for the Washington to strive for unchallenged dominance in key technologies.[68]

The CSG report called for Washington to establish an alliance of "techno-democracies" to both counter and isolate China, including the US, Japan, Germany, France, Britain and Canada, the Netherlands, South Korea, Finland, Sweden, India, Israel, and Australia (the T-12). The goal would be to "to bring together key countries to coordinate responses to technological competition." It highlighted that although the US and Chinese economies were highly interdependent, bifurcation was "inherently and necessarily" preferable for American interests. Couching an argument in ideological terms, it claimed that a failure to engineer such a split would allow China's non-Westernized political norms to "win." The paper stressed that there should be "no returning" to the more positive state of relations that had existed before the tech war, and that *status quo ante* "cannot, and should not, be a goal of our policy."[69]

At the end of 2020 Cohen and Fontaine's prominent article in *Foreign Affairs* titled 'Uniting the Techno-Democracies' advocated forming the T-12 to pursue bifurcation of global high tech and move away from globalization. While supply chains were overall politically neutral and technology standards had been set internationally since the Cold War, the paper called for the 'Western side' of the world economy to develop separate standards and supply chains. Doing so would reduce interoperability and make it more difficult for countries to cooperate with both China and the West, while also inevitably reducing trade volumes between them. The paper also raised the possibility of providing loans or loan guarantees to countries seeking 5G from the West

or Western-aligned states rather than from China, and highlighted that shared financing could be provided to move supply chains out of China and into a 'Western-aligned half' of the world economy once it was divided.[70]

Another proposal included a "framework for a digital currency that preserves the central role of the US dollar in the global financial system," which was proposed by Cohen and Fontaine on the basis that China's economic prowess threatened the dollar's central role in global trade. They stressed that the T-12 should eventually expand to unify Western-aligned states from across the world against China, including less developed countries in Africa and Latin America, to effectively draw a line through the middle of the world economy and deny China the benefits of its more competitive and increasingly more advanced high-tech goods and services. Without such radical action, they warned, trends in global technological development would transform world order and shift the balance of power against Western interests.[71] Essentially, if Western technology and currencies could not retain their dominance in a globalized world with free competition, it was seen as essential to divide the global economy and global high tech into two with challengers to Western dominance left in the 'other half' to ensure Western power could be partially sustained.

A similar proposal to the T-12 from mid-2020 known as the D-10 (Democracy-10) would include the G7 members (US, Japan, Germany, France, UK, Canada and Italy) as well as South Korea, India and Australia to address vulnerabilities in tech supply chains. The idea notably came from a proposal by President Donald Trump to expand the G7 into what was widely seen as an anti-China coalition, to which the president suggested also inviting Russia to as an eleventh member. While Russia's inclusion was widely rejected in the Western world, and was unlikely to be accepted by Moscow itself,[72] a partnership of ten focussed specifically on reducing reliance on Chinese tech and supply chains was advocated as a means of pushing back against the East Asian state's growing primacy in key technologies.[73] Similarly to other proposals for anti-China partnerships, the D-10 was widely advocated in strongly ideological terms. A notable example was an assessment by the diplomatic editor of *The Guardian,* which referred to the partners of the prospective alliance as "ideologically committed" to countering challengers to the Western-style liberal democratic system.[74]

An initiative to form an alternative to the free market of mobile applications, telecoms infrastructure and other areas of high tech launched in the Trump administration's final year, known as the Clean Network, sought to bring Western and Western-aligned countries together to exclude Chinese and other perceived undesirable actors from these sectors. It emphasized creating new supply chains for high-tech products in these countries. Those firms which complied with requirements to exclude Chinese or other undesirable

equipment would gain favorable treatment including easier access to some contracts from the US government—and possibly in future from other Clean Network members. The exact number of countries participating was somewhat uncertain, with Washington claiming over sixty countries had committed to the principles of the Clean Network. The extent to which each would abide by its loosely enforced regulations remained to be seen, however, particularly when this conflicted with their own economic interests. If successful, the initiative would be an important step toward creating two separate sets of technology standards in the world, with one being created for political reasons as an arbitrary tool to contain China. As Dr. Laurie Macfarlane, from the University College London Institute for Innovation & Public Purpose, noted to this effect: "It's no longer inconceivable to imagine a future where countries can use US technology or Chinese technology—but not both. In the longer term, a shift in this direction could fragment or even unwind the integration of our globalized economy."[75]

A leading proponent of bifurcation, and more generally of a hard line against Beijing, Secretary of State Mike Pompeo in July 2020 called for the formation of a grouping which could work to exclude China from the 'Western side' of a divided global economy. Having himself launched the Clean Network, Pompeo observed that while the United Nations, NATO, the G7 and even the G20 could all potentially play roles in Western-led efforts: "Maybe it's time for a new grouping of like-minded nations, a new alliance of democracies." Lamenting that many countries had failed to take a strong enough stance against Beijing, he stressed that the world "can't treat this incarnation of China as a normal country . . . Trading with China is not like trading with a normal, law-abiding nation." This was one of the strongest calls among senior officials for dividing the global economy.[76] "The USSR was closed off from the free world. Communist China is already here, within our borders," he stressed, alluding to the goal of a Western-led containment regime similar to that which had cut the Soviet Union[77] off from the bulk of the world economy.[78]

A prominent strategic paper from the Atlantic Council titled 'Global Strategy 2021: An Allied Strategy for China' called for the D-10's establishment and expansion to "take on a broader range of responsibilities beyond the global economy to include global security and governance." Beyond facilitating a technological decoupling from China, the paper highlighted that the D-10 "should function as a steering committee" for the West and Western-aligned states under which they could "come together, forge shared threat assessments, and develop common strategies for a broad range of issues, including China." It further raised the possibility of inviting other countries such as Sweden or Brazil if they committed to the same goals. "The D-10 could also serve to connect global resistance to Chinese aggression with

regional efforts, especially in the Indo-Pacific, the center of gravity of strategic contestation," and to "defend against China's unfair economic practices" by pressing toward decoupling, it further noted.[79]

A *Financial Times* article in October 2020 by DoD Defense Policy Board member and Executive Director of the Aspen Strategy Group and Aspen Security Forum Anja Manuel stressed that isolating Chinese technology with a Western dominated power bloc was essential because the centuries-old primacy of the Western world was itself at stake. It proposed using the D-10 to coordinate 5G standards and secure supply chains while excluding China, which would effectively split global high tech into two spheres. "Whether the west continues to lead and reap the benefits of technological innovation," it said, depended on this. It emphasized that China's moves to compete in high tech under initiatives such as Made in China 2025 "aim to end the technological lead of the west and its allies."[80]

A report from the November 2020 Halifax International Security Forum in Washington D.C. highlighted that a "free trade club" built around common ideology was potentially promising. It stated that countries in North America, Europe and Oceania, as well as non-Western states with Westernized political systems, could potentially be unified into a single grouping aimed at excluding China from a large part of the global economy. This economic bloc could "coordinate policy and investment decisions related to consumer and supply chain dependence." Former Secretary of Defense and CIA Director, Leon Panetta, was one of many to voice his support, stating at the Halifax Forum: "What is it that China fears? It fears alliances." Senator Chris Coons from the US Foreign Relations Committee referred to such a partnership in November 2020 as "a world community of democracies," stressing that the coming year would be a pivotal time to act.[81]

An article published by Council on Foreign Relations in November 2020 stressed that an alliance could be constructed to "deny China's advances in critical sectors" and for the purpose of "constraining the spread of Chinese 5G technology" while ensuring that the use of new technologies reflected Western political ideology.[82] It warned, however, that major disagreements within the Western world itself on tech standards, and even between the two major political parties in the US, threatened to undermine the possibility for the proposed bloc. It also warned that proposals for "an elite club of largely Western techno-democracies as a means to counter China's global tech influence" could be too narrow, and that more countries should be brought into the fold in an effort to block China from as many markets and as many partners as possible.[83] The *Washington Post* reported in February 2021 that a privately circulated China Strategy Group paper addressing the issue recommended the formation of "an international technology finance corporation to help countries buy Western products" over non-Western competitors and "share

research and technology with countries that agree not to buy from Huawei." It would seek to ensure that global tech standards reflected Western ideology and geopolitical interests and that China was excluded from contributing to setting standards.[84]

A further important step toward coordinating efforts to isolate China was the formation of the US-EU Trade and Technology Council. On September 28, 2021, shortly before the council's meeting, Commerce Secretary Gina Raimondo stressed that the US and Europe needed to coordinate efforts against Beijing "to hold their feet to the fire." "We have to work with our European allies to deny China the most advanced technology so that they can't catch up in critical areas like semiconductors. We want to work with Europe, to write the rules of the road for technology, whether it's TikTok or artificial intelligence or cyber." Alluding to ideology as the reason for doing so, she stressed: "We don't want autocratic governments like China, writing the rules of the road . . . we need to write the rules of the road," stressing that the final goal was "to slow down China's rate of innovation" by isolating its tech sector.[85] The strong emphasis on ideology, and references to allowing China as a non-Western and politically non-Westernized state to rise to primacy as "anti-democratic," were common to most calls for a tech alliance to isolate the West and its partners from the East Asian country.

BIFURCATION: OBSTACLES AND CONSEQUENCES

As World Trade Organization reports and papers observed on multiple occasions, "an enduring peace depended fundamentally on international economic cooperation."[86] Where globalization and economic interdependence had long been seen to deter hostilities, bifurcation by contrast drew comparisons to inter-European relations in the 1930s and to Soviet-Western relations in the Cold War.[87] Leading US trade policy expert and former economist for the Executive Office of the President's Council of Economic Advisers, Professor Douglas Irwin was among several experts to observe that the fallout from the COVID-19 pandemic presented an ideal opportunity to push for accelerated bifurcation. He stated in May 2020: "When you're at a high level of economic activity, when unemployment is low, you'd see the pain if you pull all that apart. But now that everything is scrambled, it's easier in some sense to pull back. This artificial contraction makes it easier not to go back to how things were before."[88] Using COVID-19 as a starting point for bifurcation was widely advocated, including in Cohen and Fontaine's 'Uniting the Techno-Democracies' paper. Regarding the possibility for a sharp reversal of the prevailing trend toward globalization, Irwin stated: "I think there are some quarters in the United States that really do want to go that far . . . and give up

some of the gains they might have from being open and integrated. So these things can spiral—that's certainly the story of the 1930s."[89] He concluded: "you won't have the globalization you had in the past. How far you down the road in reversing that is to be determined."[90]

Where Western calls for bifurcation were made on the premise that continued integration would continue to benefit China, perceptions of unprovoked American hostility led to calls in China for a more conservative separation. In contrast to the West, however, such arguments were almost never made in ideological terms and were instead advocated on the basis that the US would otherwise seek to leverage interdependence to undermine China's economic modernization as it had in the Trump years. The targeting of Huawei was the most often cited example. The head of China's Central Policy Research Office Jiang Jinquan stated to this effect in January 2021 that it was vital to "develop autonomous capabilities in key industrial areas . . . to reduce reliance on foreign technologies, equipment and key components, especially those from Western countries." This was necessary to respond to Washington's efforts to "significantly disrupt our external technology exchanges and cooperation." Pursuit of a wider range of "strategic and fundamental key science and technology projects" were crucial, according to Jiang, for China to avoid "being strangled by others at the neck."[91]

Jiang's statements reflected a growing consensus, with prominent Beijing University professor Wang Yong similarly stating that China had learned under Trump's presidency that "the US is a very unreliable supplier of hi-tech technology and key technical components . . . It's difficult to count on the US. As such, China must have independent and innovative strength."[92] What was being advocated was not a broad undermining of trade relations or an economic war to stifle the US, but rather a securing of supply chains which the West could seek to target in future in response to the dangers demonstrated by Washington's recent policies. The president of the Chinese Academy of Sciences Bai Chunli stated to this effect in September 2020 that the technology fields targeted by Washington would be mirrored in the areas prioritized for development under the upcoming Five-Year Plan.[93] Beyond high tech, although mainland Chinese manufacturing was already far less dependent on exports than Japan, South Korea, Taiwan or Germany,[94] with the proportion of GDP from exports halving from 2006 to 2019 from 64 to just 32 percent,[95] broader efforts were taken to accelerate the shift toward a greater reliance on domestic demand.[96] This was again widely interpreted as a shift by Beijing to secure itself against expected future Western economic warfare efforts.[97] The fact that China continued to expand its lead over others as the world's largest trading nation at a fast-growing rate, however, undermined claims that this represented an inward shift.

As momentum built toward a technological decoupling, the global economy and consumers on both sides were set to lose out with firms caught in the middle forced by politically motivated polices to choose a side. Senior fellow at the Carnegie Asia Program James L. Schoff observed regarding this:

> technological decoupling . . . could result in two broad sets of standards and protocols. Such a decoupling would create all sorts of inefficiencies but might provide more security assurances. Banning equipment that poses a security risk to US government agencies might be justified in certain cases, but if such bans limit information and market access for US and Japanese companies—as well as their business development opportunities—then it could have long-term negative effects. If, for instance, Huawei's 5G technology becomes the dominant standard in several countries around the world while a competing European-US-Japan consortium makes gains in other nations, each market will become smaller, less efficient, and less interoperable with the rest of the world. The problem would be worse for the allies if leading European and Korean companies chose not to limit their commercial opportunities in that way and collaborated with Chinese firms instead.[98]

Taking Japan an example of the tech war's implications for firms outside the US which were forced to fall in line with new trade war policies due to their government's political alignment, Schoff wrote:

> Japanese companies have to adapt to the US government's tightening restrictions on technology, such as stricter export controls, investment restrictions, and prohibitions on doing business with certain Chinese firms. For example, the transfer of an algorithm developed by a Japanese company in a laboratory in Silicon Valley to its Japanese headquarters may require the approval of the US government. What's more, transferring such information to a Chinese subsidiary will be even more difficult. Large US firms face the same challenges.[99]

The tech war against China placed firms from Western-aligned countries doing business with the world's largest economy in the firing line, for example by preventing a Japanese firm from selling a building materials subsidiary to a Chinese firm under the threat of itself being targeted by Washington.[100] Many experts including Schoff highlighted that a decoupling of technological standards could be highly counterproductive and risked allowing China to take the lead and China-led standards being widely adopted. Much as decoupling was intended to restrict Chinese firms' ability to compete on the 'Western side' of the global economy, so too could it limit economic opportunities for US and allied competitors attempting to do business internationally beyond this confined space.

As Washington took a harder line against firms operating in China the extraterritorial application of American law increasingly caught them between needing to comply with contrasting regulations in the two countries. Professor at Marine Corps University Jill Goldenziel observed regarding how this affected the communications sector: "Businesses must walk a fine line between complying with Chinese government demands and US Constitutional guarantees . . . US communications providers may soon face a choice: restrict or halt their business activities in China or face legal consequences in the United States."[101] Countering this new Chinese regulations from January 2021 made third-party non-American entities in China, such as Taiwanese semiconductor firms, punishable if they adhered to Washington's demands such as stopping supplies of goods or services to Chinese firms. The bylaw was titled: 'Regulations to Stifle Improper Extraterritorial Application of Foreign Laws and Measures,' and was hailed as a response to Washington's "extraterritorial excesses." This would force firms to either face American or Chinese charges, and although proportional was a further step toward bifurcation by making them more decisively choose sides.[102]

Possibly the most significant obstacle to escalating bifurcation efforts was that repatriating industries to the West remained totally unviable, and while it was potentially more feasible to shift supply chains out of China and toward other Asian countries even this was highly unlikely due to the many very unique benefits China offered. Firms such as Apple and Tesla would staunchly resist giving up such benefits. As China expert and former *Financial Times* bureau chief in Hong Kong, Rahul Jacob, noted:

> Production lines and supply chains are far more sticky than most people seem to understand. It is very difficult to pull them apart overnight . . . China offers integrated infrastructure like large ports and highways, top quality labor and sophisticated logistics, all of which are critical factors to meet strict deadlines that international companies operate on.[103]

India was raised as one possibility by a number of Western analysts although a very different work culture and political system, and as a result of the latter poor infrastructure and public health and questionable political stability, largely ruled out a shift of industry to the country on a significant scale. The extremely stark contrast in the effectiveness of government in handling COVID-19 between India and competitors further east such as China and Vietnam was interpreted by many analysts as a strong indicator of the general discrepancies and the much greater challenges investors would face in the former.[104] India's federal system, which meant laws were often very different in different regions, only further complicated matters for investors.[105] A notable example of the kinds of issues faced came in December 2020 when a

small new iPhone assembly plant in southern India set up on a trial basis saw property smashed and set on fire in a riot by the majority of the 2000 workers employed there.[106] Ironically, the opening of the plant had been widely hailed as heralding the shift in manufacturing to the country.[107] Suffering a wide range of other workforce-related issues in India, Apple's leading contract manufacturer Foxconn began to again expand recruitment on the Chinese mainland in 2021.[108] Other than Foxconn, other Taiwan-based tech firms seeking to shift production to India faced 'culture shocks' and struggled to adapt in particular to managing local workers.[109] An apt analogy to attempting to move supply chains from China to India was attempting to domesticate a zebra to replace a horse—it may have looked like a basic switch but those familiar with the two would know it to be near impossible. A growing number of analysts in both the West and in India itself came to recognize this with time.

BIDEN'S ESCALATION

The shift toward greater government intervention in the US economy accelerated under the Joe Biden administration from January 2021 with a renewed focus on bolstering the tech sector. This was pursued while keeping Trump-era measures against Chinese high tech in place and expanding measures targeting strategic areas such as supercomputers.[110] Although avoiding the extreme rhetoric observed from Trump administration officials in 2020, Biden's administration was seen by many US analysts to be taking an even harder line against Beijing.[111] Appointing Brookings Institution scholar Rush Doshi as China director on the National Security Council was interpreted by analysts as an early signal that the administration would take a hard line.[112] Doshi advocated a policy focus on "blunting Chinese power and order and building the foundations for US power and order," and had long framed Chinese economic growth and modernization highly negatively as an imminent threat to America.[113] By April President Biden appeared personally "committed to a distinctly anti-China global strategy rooted in fears of American decline," as observed by *The Nation*.[114] Consequences went far beyond the tech war, with a flurry of efforts to 'deprioritise the Middle East,'[115] improve ties with Russia[116] and Iran[117] and withdraw forces from Afghanistan[118] all being pursued rapidly with the same focus of freeing up resources and attentions to focus on China.[119]

In March 2021 at the first meeting between high-level US and Chinese delegations under Biden in Alaska the hosts were accused of serious breaches of diplomatic protocol, "inhospitable" behavior, and of having made "unreasonable attacks and accusations of Chinese domestic and foreign policies,

and provoked quarrels."[120] State Secretary Anthony Blinken attested to his delegation's intentions before the meeting in terms *Foreign Policy* described as "about as undiplomatic as he could be." "Washington would be mostly laying down demands. Only evidence of 'tangible progress' by China would lead to more talks," it warned, stressing that Blinken was issuing "something close to ultimatums" as opposed to diplomacy. The meeting made clear that Beijing would continue to be viewed and treated as an adversary.[121]

On May 26 President Biden announced that $52 billion of government funds would be allocated to supporting semiconductor production and research over the next five years, with Commerce Secretary Gina Raimondo stating that this could support between seven and ten new factories.[122] That month under a proposed $1.7 trillion infrastructure plan, $174 billion was allocated to boost domestic electric vehicle production with tax credits and outright grants for battery manufacturers among other incentives.[123] A broader push to boost America's tech sector otherwise focused on AI and electric cars with the allocation of over $100 billion in funding to each, with the Commerce Department also organizing a June conference to attract more electric vehicle manufacturers.[124]

The Biden administration oversaw a very abrupt shift away from prevailing free-market norms with firms artificially isolated from foreign competitors and backed by a new mobilisation of state investment. The *Washington Post* noted: "Biden's goal is to move beyond protecting against Huawei to promoting alternatives. That might mean investment in cross-border joint ventures with competitors such as Ericsson, Nokia and Samsung. It might mean a common embrace of new technologies such as open radio access networks, or O-RAN, a software-based approach to 5G networks." Such policy, the *Post* noted, "carries echoes of what used to be known as 'industrial policy.' Critics will argue that such decisions should be left to the free market."[125]

The Biden administration was expected to continue pursuing bifurcation with a greater emphasis than its predecessor on forming blocs to isolate China. As a presidential candidate Biden had emphasized the need "to build a united front of friends and partners to challenge China's abusive behavior," stressing "there's no going back to business as usual on trade . . . We must negotiate from the strongest possible position. On our own, we represent about one-quarter of global GDP. When we join together with fellow democracies, that number doubles. China can't afford to ignore half the global economy." Pressing the West and its partners to close ranks was intended to advantage Washington and allow it to effectively dictate terms.[126] The goal was to ensure that the US would "shape the future rules of the road on everything from the environment to labor, trade, technology and transparency so they continue to reflect democratic interests and values—America's interests and values. Not China's. Not Russia's."[127]

Biden emphasized in one of his first statements as president-elect: "We make up 25 percent . . . of the economy in the world. We need to be aligned with the other democracies, another 25 percent or more so that we can set the rules of the road." He stated that such an economic coalition was vital to countering China.[128] Biden later stressed: "as we compete with China . . . our position will be much stronger when we build coalitions of like-minded partners and allies to make common cause with us in defense of our shared interests and values."[129]

Referred to by China's *Global Times* as "tech containment" to isolate China,[130] Biden's administration appeared to be prioritising bifurcation. Biden made the first overseas visit of his presidency to Europe in June, and shortly before leaving announced: "My trip to Europe is about America rallying the world's democracies."[131] If there was any ambiguity as to what they were expected to be rallied for, the BBC clarified in the headline of its coverage that Biden intended "to urge West to form alliance against China at the G7 summit."[132] Former US defense official Barry Pavel was one of many analysts to observe regarding the president's tour of Europe: "the issue of China will be woven throughout every single meeting on his agenda."[133]

On June 6, five days before the summit, Biden announced regarding his agenda: "We will focus on ensuring that market democracies, not China or anyone else, write the twenty-first century rules around trade and technology." He stressed the need to ensure high tech was shaped by the West and its ideology, stating: "the democracies of the world must together ensure that our values govern the use and development of these innovations."[134] Such statements were far from unprecedented, with President Obama having similarly worked to form an economic bloc to provide favorable trade terms to countries aligned with Western interests—the Trans-Pacific Partnership.[135] Regarding its importance Obama had stated in 2016: "America should write the rules. America should call the shots. Other countries should play by the rules that America and our partners set, and not the other way around."[136] Both presidents' statements strongly implied that the countries which wrote the rules, in Biden's case for tech and in Obama's for trade, should be determined by affiliation with Western interests and by ideology rather than by normative economic or technological measures.

As previously noted by analysts at the Atlantic Council, among others, Biden's foreign policy strongly emphasized ideology—dubbed a "pro-democracy strategy"—which provided an optimal seam along which to pursue bifurcation. Using ideology as the dividing line against China, rather than geopolitics, civilization or trading relationships, provided a wider pool of countries that could be won over to the 'Western side.'[137] With ideological differences between the West and China being at the center of America's efforts to draw European states more firmly onto its side against Beijing,

NATO Secretary General Jens Stoltenberg notably emphasized shortly preceding Biden's trip, in the latest of many similar statements, that China "don't share our values."[138] This was followed by multiple statements both from the alliance and from members calling for expansion to focus on East Asia and countering China – what British Foreign Secretary Liz Truss referred to as 'Global NATO' which could secure Western interests in the Taiwan Strait.[139]

The G7 summit unprecedentedly saw the leaders of Australia, India and South Korea attend as guests, which was widely interpreted as a step toward expand the grouping into something resembling the D-10. Meetings were contentious with *CNN* reporting citing US sources present that "the disagreements, aired during a session . . . at one point became so sensitive that all internet was shut off to the room." With the US, Britain, France, and Canada reportedly pushing for a harder line against China than others were willing to accept, it was predicted after the first day that little concrete action would be taken.[140] As Britain's *Guardian* noted the following month: "Biden's biggest weakness is a lack of solidarity among US allies whose support is vital for his policy's success," with Washington's ideological arguments persuading few to risk alienating the world's largest economy.[141] The G7's statement condemning Beijing at the summit's closing was far from outstanding and much less strongly worded than those coming from Washington, London or Ottawa.[142]

The Biden administration increasingly began to send mixed messages regarding its intentions. By July it had moved to crack down harder on China's access to semiconductors,[143] set up a 'strike force' led by the US Trade Representative targeting Chinese goods in key supply chains,[144] escalated the targeting of the Chinese economy with sanctions[145] and placed more restrictions on investments in Chinese firms.[146] Despite Washington's initial hard line on talks, however, three rounds of high-level trade talks were held in late May and early June. China's Commerce Ministry referred to a "candid, pragmatic exchange of views" focusing on trade and investment cooperation, although no concrete agreements were announced beyond pledges to hold further meetings.[147] Beset by serious domestic social and economic issues, Washington made no major escalations and made a significant conciliatory gesture by dropping charges against Huawei's chief financial officer and deputy chair of the board Meng Wanzhou in September. Meng had been detained in Canada awaiting extradition to the US since December 2018,[148] with her detainment widely seen as part of broader efforts by Washington to stifle Huawei.[149] Her release was optimistically hailed by some in China as an opportunity to create a turning point in relations, and was followed by a re-establishing of dialogue in the spheres of trade, climate and defense.[150] Waning support for the Clean Network, which had been pushed by Trump administration officials but increasingly appeared to lose momentum under

Biden, and reversing the preceding administration's moves in its final weeks to begin targeting Oppo following its attacks on Huawei, were other notably early conciliatory steps. Flaring tensions with Russia and Belarus from October, which the Trump administration had specifically sought to avoid to focus attentions on China, further pushed tech war and China-related issues down the new administration's agenda.

Although the Biden administration faced considerable private sector pressure to ease tensions, a possible relaxation of Trump-era tariffs and trade restrictions which the WTO had ruled violated its terms[151] was a much more likely concession than a broader easing of the targeting of China's tech sector. As *Politico* noted in mid-August: "America's largest corporations are voicing frustration that Biden has not rolled back any of former President Donald Trump's major tariffs, particularly the duties on $350 billion worth of Chinese imports."[152] Beijing's responses to tariffs with trade restrictions of its own had seriously undermined American exports to the country,[153] and some analysts expressed hopes that loosening trade restrictions would create the cooperative climate needed for de-escalation of the tech war. Pressure continued to mount in the following months,[154] but in January 2022 Biden ruled out such a possibility in the near future.[155] As the economic situation in the US worsened that year, however, and with tariffs on Chinese goods imposing considerable costs on American consumers and fuelling inflation, Treasury Secretary Janet Yellen in April said removing tariffs was an option that needed to be considered.[156]

Facing a range of policy issues, from COVID-19 and economic crisis to Iran's nuclear program, scandal surrounding the pullout from Afghanistan, and from February 2022, open war in Europe, administration positions on the tech war, and on China more generally, appeared uncertain if not confused. Whether the conflict would move toward further escalation, or whether under pressure from a flagging economy, a tenuous situation for the dollar and significant private sector lobbying the administration could move toward deescalating remained highly uncertain throughout its first year. Bifurcation increasingly appeared to be less of a priority with the state of the US economy, the immense costs involved, and considerable resistance from strategic partners, meaning it was not likely to be seen through. Continued integration would almost certainly ensure greater prosperity for the United States, its citizens, its firms, and its allies, but would also remove the threat to Chinea of a destabilized global economy and loss of Western markets which, while harming all major economies, could have potentially slowed the power trajectories in Beijing's favor.

DEFICITS TO FUND THE TECH WAR: IS AMERICA'S POSITION SUSTAINABLE?

The Biden administration quickly proved to be one of the least conservative spenders in US history leading to widespread concerns for the future status of the US dollar and the consequences of the explosion of debt it oversaw. The bulk of spending was focused on accelerating moves that had begun in 2020 toward greater government intervention to bolster the American industry, although this spending was heavily financed by debt and further enlarged the country's already very substantial budget deficit. Much like the Soviet Union in the 1980s, which spent unsustainably on defense to retain a strong position against the United States, there increasingly appeared a possibility that Washington's extreme new expenditure levels could push the economy past a point of no return and to the brink of default on its debts. With the US' future economic health in serious question, in particular its ability to retain its position at the heart of the global economy with its currency as the global reserve, whether or not the economy and government spending remained stable became a potentially decisive factor in determining the outcome of Sino-US technological competition.

As former Asia Director on the US National Security Council and advisor to President Donald Trump, Matthew Pottinger, was one of many to highlight in 2021 in the context of competition with China: "One of the strongest tools we have is our dominance in finance. Capital markets and the reserve currency status of the dollar that we talked about."[157] This position has not only provided leverage to threaten third parties, including to deter them from working with China or its firms, but also finances US government spending and its tremendous budget deficits. An undermining of the dollar's position could swiftly end prospects for America to prevail in the tech war, with the currency facing growing pressures including from economic crisis in 2020, the internationalisation of competing currencies, and the emergence of crypto and digital rivals.[158] China's positioning of its central bank digital currency to capitalize on first mover advantages was seen by some economists to threaten a "new global monetary order" contributing to undermining the dollar's position.[159] More pressing was the unprecedented rate of debt accumulation, with the US debt to GDP ratio surpassing 1:1 in 2020[160] as deficits that year reached a staggering $3.13 trillion or 15.2 percent of GDP.[161] Federal Reserve Chairman Jerome Powell was one of many to warn that year that the budget was "on an unsustainable path, has been for some time."[162]

Major budget deficit increases under the Biden administration led economists to predict that the debt to GDP ratio would reach a phenomenal 2.77:1 by 2029, meaning $89 trillion of debt, which threatened to substantially

lower the value of Treasury bonds.[163] As the country came close to its first ever default in September-October 2021, this was seen as an early sign of serious strain which further threatened bond value.[164] This was followed by signs that not only China, but even allied Japan which was the leading holder of American treasuries, was among others quietly selling off bonds.[165] The stability of Treasury bonds had long been tied to the US dollar's position as the global reserve currency, and a long default on bonds combined with pressures from competing currencies could threaten this position and seriously curb future government spending.[166] An extreme debt to GDP ratio would also increasingly constrain the government's ability to function, as interest payments alone would consume a growing share of tax dollars at hundreds of billions annually likely surpassing the cost of funding the US military by the mid-late 2020s. With no economist predicting anything approaching a balanced budget, let alone a surplus to reduce debt levels, the possibility for fiscal crisis grew which could effectively take America out of the tech war. Thus while China's government spent within its means and often generated budget surpluses,[167] US government expenditures were well beyond its tax revenues and were financed through extreme and unsustainable debt accumulation. Government funding for the tech war, whether directly or through provision of infrastructure, education and other services relied on by private tech firms, could not be sustained. A crisis that seriously harmed the US tech and defense sectors, in turn likely further contracting GDP and fuelling a downward spiral, could be the most likely avenue for a quick and decisive end to the tech war by removing America as a peer competitor.

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Conclusion

The contest for dominance of key areas of high technology has increasingly come to be recognized as the most pivotal area of great power competition in the twenty-first century. President Xi Jinping warned to this effect when addressing the Chinese Academy of Sciences in May 2021: "Technological innovation has become the main battleground of the global playing field, and competition for tech dominance will grow unprecedentedly fierce."[1] Although it played significant roles in deciding the outcomes of major twentieth century conflicts, the much faster and still accelerating pace of technological development today and its greater role in facilitating state power has given high tech an unprecedented degree of importance in shaping the global balance of power. To a greater extent than at any time before, technology holds the key to primacy in all areas of state power. Innovation and the ability to develop more sophisticated and cost-effective products are vital to the health of both civilian economies and defense industries. In the information space gaining first mover advantages in new generations of communications and media technologies to create the most popular platforms and content is a key facilitator of greater soft power and the ability to exert a greater influence on thought and public perceptions across the world. Thus a more dynamic, innovative and productive technology sector can translate into tremendous advantages on multiple fronts.

While it is a near certainty that China or the United States will be the dominant technological powers of the twenty-first century, Beijing and Washington have profoundly different visions for the nature of world order and the future of humanity. Continued American primacy will effectively facilitate a continuation of a centuries-old world order dominated and shaped by Western power, with the US being the successor to the empires of Britain, France, Spain, Holland and Portugal as the primary guarantor of this order and rallying the West behind it to assert leadership globally. A world order shaped by Chinese primacy, by contrast, would represent a return to the status quo preceding Europe's imperial expansion and global hegemony. China had

been the world's largest economy and the leader in science and technology for most of human history until the Opium Wars entered it into its most calamitous century. The millennia when China was the world's greatest power saw a laissez faire international order in which the East Asian state demonstrated little ambition for global empire or the imposition of its ideology, way of life, religion or method of governance abroad in stark contrast to the Western-led order which succeeded it. A gradual return to this kind of multipolarity is expected should China prevail in the current economic and technological competition.

The outcome of competition between China and the United States for technological primacy will thus determine the future of world order with profound implications for all countries and peoples. China today is unrivalled in the prevalence of technical skills in its workforce, in the concentration of manufacturing supply chains on its territory, and in the speed of its economic growth. The United States by contrast has the advantage of a much greater global influence established primarily through soft power and the export of its media and ideology, the global reach of its military and intelligence agencies, its large network of treaty alliances, and its position at the center of the global financial system. This influence has key implications not only geopolitically and militarily, but also for technological and economic competition by allowing Washington to move countries across the world to conduct policy more closely in line with its interests and to draw talent from abroad to its shores. The two superpowers are thus fundamentally different not only civilizationally and ideologically, but also in the kinds of assets they depend on. China is by a fast-growing margin the more industrialized country, while the US is very much a global empire with a greater ability to shape the wider world.

The significance of the tech war and the magnitude of the stakes at play have often been overlooked, but become evident when considering the low likelihood that such a technological competition could reoccur in the foreseeable future. Where a century prior new players could quickly emerge as leaders in industry by developing entire value chains domestically, as the USSR did in the 1930s and Japan from the 1890s, the impossibility of doing so with value chains globalized effectively excludes the possibly of new leading industrial powers emerging independently. Not only is the gap between the technological leaders and the rest of the world growing, but it is growing at an accelerating rate making it increasingly impossible for new players to ever hope to compete at a similar level to the US or China.

China from 1949, at a continuous and rapid rate of progress and initially with very considerable Soviet economic support,[2] took close to seventy years to largely bridge the technological gap with and become a peer level competitor to the dominant Western powers. For an aspiring new country today seeking to eventually compete as a top end industrial and technological power

the task will be increasingly impossible. One of the many examples of how barriers to entry into high end technological and economic competition have been raised significantly by technology trends was described by veteran tech investor and leading AI authority Lee Kai-fu as follows:

> AI-driven automation in factories will undercut the one economic advantage developing countries historically possessed: cheap labor. Robot-operated factories will likely relocate to be closer to their customers in large markets, pulling away the ladder that developing countries like China and the 'Asian Tigers' of South Korea and Singapore climbed up on their way to becoming high-income, technology-driven economies. The gap between the global haves and have-nots will widen, with no known path toward closing it.[3]

With Imperial Japan and the USSR, which in the twentieth century were the world's only top tier non-Western industrial countries capable of challenging Western technological primacy, both having been removed from the map, and with the emergence of new top-level players in high tech being increasingly unlikely, China could be the last technologically peer level challenger that the West ever faces. In this context it can be understood that while a Chinese victory in the tech war could bring a final end to world order based on Western hegemony and backed by Western technological primacy, the East Asian state's defeat could seal the world's fate to an 'end of history' and indefinite Western hegemony.

Francis Fukuyama and others like him were proven to have been premature in declaring an 'end of history' when the Cold War concluded. Indeed, an ideological 'end of history' and settling on a single political and economic system indefinitely is impossible so long as humans rule themselves. Human nature dictates that successive generations will have a tendency to experiment with new ways of thinking and of organizing themselves meaning an eternal 'Western liberal democracy' for the whole world as Fukuyama and others predicted was never realistic. Still the tech war could portend a much more serious 'end of history'—namely that the balance of economic and technological power, and with it inevitably the military balance, will be irreversibly decided in the coming fifteen years or less in favor of one center of power or another.

The US' ability to maintain stability in its economy, the position of its currency and particularly its government spending levels, remains in serious question as its budget deficits grow more extreme. As annual interest payments on debt are set to surpass the entire Pentagon budget before 2030, the state of its economy could force very deep cuts to government spending and otherwise seriously impede America's ability to compete in the tech war. Beyond these economic issues, the US tech sector's extreme reliance on foreign talent remains another serious issue which would require unprecedented

reform of the education system and education culture to resolve. The ability to attract talent among other factors relies on sound immigration policy, sustainment of soft power, clear advantages over emerging competitors, and economic stability, with the country's ability to sustain these being questionable. As China is vilified in Western press there are growing signs that East Asian talent in particular, increasingly alienated by discrimination, government suspicions and rising hate crimes, will look abroad.

China has the important advantages of a larger, faster growing and significantly healthier economy and industrial base. Its domestic pool for STEM talent is not only far greater and its population better educated, but the discrepancy with the US in these fields is increasing rapidly with all major indicators ranging from PhDs completed and patents filed to schoolchildren's PISA tests pointing strongly to this trend. China's political system has also increasingly been seen even by Western analysts as better suited to supporting a world leading tech sector. A notable example was government funding of R&D in key areas which had been a consistent part of Chinese economic planning since the 1950s, and which in sharp contrast to the US grew steadily as a percentage of GDP keeping up with the country's rapid economic growth. This ensured funding in strategic areas where the private sector may otherwise not have been willing to work. As the editors at the *MIT Technology Review* observed: "Governments are more likely to fund long-term, risky bets like clean energy, sustainable materials, or smart manufacturing—the kinds of technologies the world really needs right now . . . it's become increasingly clear in the West that while the venture capital model is good at building things people want, it's less good at producing things society needs in order to solve hard, long-term problems like pandemics and climate change."[4] They further elaborated: "economists, like MIT's Daron Acemoglu, argue that letting Silicon Valley set the agenda has not only limited innovation to the types of inventions that can make quick profits, but contributed to the growth of inequality." This was effective in boosting GDP and creating jobs in the short term but in the long term left the US in a much weaker position to compete in strategically vital technologies.[5]

The emergence of Chinese primacy in all strategic technology areas including AI, 5G, quantum science, semiconductors, green tech and biotechnology, was increasingly projected as the most likely future based on prevailing trends. A December 2021 report from the Harvard Kennedy School of Government, for example, emphasized that only a "national response analogous to the mobilization that created the technologies that won World War II" had a chance of preventing total Chinese dominance of "the technologies of the future." It concluded that in some areas China "has already become No. 1. In others, on current trajectories, it will overtake the US within the next decade."[6]

Should the US be able to remain a peer level competitor to China, conflict could well last into a phase where the human experience and daily life for the populations of developed countries changes very fundamentally. The shift is likely to be orders of magnitude greater than that brought about in the 2010s by the proliferation of smartphones and mobile data. Two fields which could be particularly transformative are artificial intelligence and advances in neuroscience—namely those which could allow human brains to be connected directly to machines, to the internet and even to AI. Research into the latter is ongoing in China and the United States, with tech entrepreneur Elon Musk's Neuralink startup having publicized its success in April 2021 in allowing monkeys to interface with computers and play video games through implants in their brains.[7] Preparations for clinical trials on humans began in January the following year.[8] Musk predicted that not only would language learning soon become obsolete, but that language itself would fundamentally change as brains with neuro implants would presumably find more efficient means of communicating through computer languages.[9] This represented one of many examples of how technological competition and advancement was poised to profoundly alter the human experience, meaning the tech war will likely end in a very different world to that which existed when it began.

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菊厂影业Fans on Weibo, '其实不必意外，鸿蒙对高通平台的适配很早就有预案了，不仅仅高通平台，其他如联发科等平台也会有适配方案。作为开源系

统，不适配我才觉得奇怪。另外已经有非常多的厂商开始接受鸿蒙了，不仅仅是家电，汽车企业，还有一些手机厂商也在接触，并且有计划适配。至于哪些厂商就暂时不透露了，到时候一定会有惊喜。安卓时代的格局，不代表未来。华为#数码迷##华为##华为鸿蒙有望下月规模化推送#。[In fact, it is not surprising that Hongmeng has a plan for adapting to the Qualcomm platform for a long time. Not only the Qualcomm platform, but also other platforms such as MediaTek will also have an adaptation plan. As an open source system, I find it strange that it doesn't fit. In addition, a lot of manufacturers have begun to accept Hongmeng, not only home appliances, automobile companies, but also some mobile phone manufacturers are also contacting, and have plans to adapt. As for which manufacturers will not be revealed for the time being, there will be surprises at that time. The pattern of the Android era does not represent the future. Huawei#数码迷##武汉##Huawei Hongmeng is expected to push on a large scale next month#], May 7, 2021.

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